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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Kiichiroh IIJIMA et al.

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CLAIM FOR PRIORITY

Director of the U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir:

The benefit of the filing dates of the following prior foreign applications filed in the following foreign country is hereby requested for the above-identified patent application and the priority provided in 35 U.S.C. §119 is hereby claimed:
Japanese Patent Application No. 2001-157832 filed May 25, 2001 and
Japanese Patent Application No. 2001-281921 filed September 17, 2001.

In support of this claim, certified copies of said original foreign applications:

__X__ are filed herewith.

_____ were filed on _____ in Parent Application No. _____ filed _____.

_____ will be filed at a later date.

It is requested that the file of this application be marked to indicate that the requirements of 35 U.S.C. §119 have been fulfilled and that the Patent and Trademark Office kindly acknowledge receipt of these documents.

Respectfully submitted,

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【プルーフの要否】　要

【書類名】　明細書
【発明の名称】　駆動力伝達装置及びこれを用いた画像形成装置
【特許請求の範囲】
【請求項１】　一若しくは複数の無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置において、
平ベルトの少なくとも一つには平ベルトの進行方向に沿って複数列の貫通孔を設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を当該張架部材の回転方向に沿って複数列設けたことを特徴とする駆動力伝達装置。
【請求項２】　請求項１記載の駆動力伝達装置において、
平ベルトの進行方向に直交する幅方向に対して隣接する貫通孔の各々は、平ベルトの進行方向に対して相互に重複しない位置に配置されていることを特徴とする駆動力伝達装置。
【請求項３】　駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、
駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、
平ベルトの少なくとも一つには進行方向に沿って複数列の貫通孔を設け、平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を当該張架部材の回転方向に沿って複数列設けたことを特徴とする画像形成装置。
【請求項４】　一若しくは複数の無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置において、
駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して同軸で且つ自由回転可能な自由回転体を設け、この自由回転体が設けられた張架部材とは異なって隣接する張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたことを特徴とする駆動力伝達装置。
【請求項５】　請求項６記載の駆動力伝達装置において、

平ベルトの少なくとも一つには進行方向に沿って一若しくは複数列の貫通孔を設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を設けたことを特徴とする駆動力伝達装置。

【請求項６】　請求項６記載の駆動力伝達装置において、

自由回転体は、張架部材の回転軸の軸方向に対し位置規制部材にて位置規制されていることを特徴とする駆動力伝達装置。

【請求項７】　請求項６記載の駆動力伝達装置において、

自由回転体は、掛け渡される平ベルトの進行方向に直交する幅方向に対する位置を規制する位置規制部を具備していることを特徴とする駆動力伝達装置。

【請求項８】　駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、

駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して同軸で且つ自由回転可能な自由回転体を設け、この自由回転体が設けられた張架部材とは異なって隣接する張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたことを特徴とする画像形成装置。

【請求項９】　駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置として、請求項１又は４記載の駆動力伝達装置を用いたことを特徴とする画像形成装置。

【請求項１０】　請求項３又は８記載の画像形成装置のうち、二系統の像担持体を備えた画像形成装置において、

駆動力伝達装置は、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えたことを特徴とする画像形成装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、複写機，プリンタ，ファクシミリ若しくはこれらの複合機のような画像形成装置などに用いられる駆動力伝達装置に係り、特に、無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置及びこれを用いた画像形成装置の改良に関する。

【０００２】

【従来の技術】

プリンタや複写機等の画像形成装置に利用される駆動力伝達装置には、その不良が直ちに画像欠陥へと繋がるという性質上、高噛み合い率、高伝達性、回転ムラの抑制など、様々かつ高度な要求を満たすことが求められている。

従来における画像形成装置の駆動力伝達装置として、高噛み合い率と高伝達率の実現、あるいは良好な低回転ムラ性能を得るために、はす歯歯車を用いて像担持体ドラムへ駆動力を伝達する技術が提案されている（例えば特開平９－８０８４０号公報，特開平５－７２８６２号公報参照）。

また、はす歯歯車を用いるよりも低回転ムラ性能が実現できる駆動力伝達部材として、歯付きベルトを用いる技術も提案されている。

更に、歯付きベルトより低回転ムラを実現するために、はす歯ベルトを用いる技術も提案されている（例えば特開平９－１６０３３２号公報，特開平１０－２６９０３号公報参照）。

【０００３】

一般に、駆動力伝達部材として、はす歯歯車を用いた場合は、すぐ歯歯車を用いた場合と比較して噛み合い率を大きく取り易く、駆動歯車と従動歯車との噛み合いがゆっくりと行われるため、従動歯車に伝達される噛み合い振動をかなり低減することが可能であることが分かっている。しかし、歯車を駆動力伝達部材として用いた場合には、バックラッシュによる回転ムラの発生という技術的課題は避けられない。

すなわち、駆動歯車が従動歯車と噛み合って従動歯車を回転駆動する際に、駆

動歯車の歯と従動歯車の歯とは所定の時間だけ互いに接触しているが、その時間が過ぎ、次の歯同士が噛み合うまでの間にお互いの歯同士が非接触状態になり、これがバックラッシュ（がた）である。このため、バックラッシュは、次の歯同士が噛み合う時に振動を発生させ、従動歯車には周期的（歯車の歯同士が噛み合う繰り返し）な回転ムラが発生する要因になってしまう。

このバックラッシュは、歯車を用いる場合には原理的に避けられないものであり、画像形成装置の駆動力伝達部材として歯車を用いた場合には、従動歯車が噛み合いによって加振され、非拘束状態となるバックラッシュ分だけ容易に動かされてしまうため、噛み合い振動による小さな加振力でも出力画像に周期的な濃度ムラを発生させてしまうことになる。

【０００４】

また、はす歯歯車を用いたとしても、すぐ歯歯車を用いた場合と比較して、噛み合い歯数を大幅に増やすことは不可能であるため、歯の変形問題を考慮すると、特に噛み合い接触部においてある程度の硬度を有する材料で歯車を製作する必要がある。

しかし、硬度の高い材料で形成された駆動歯車と従動歯車とが噛み合う場合には、噛み合いによって生じる振動を吸収する部分が駆動力伝達経路内（歯車列により幾つかの回転体を駆動する場合の伝達経路内）に存在しなくなるため、駆動歯車と従動歯車とが噛み合うことにより発生する噛み合い振動は減衰されずにそのまま従動歯車へ伝達され、その結果、出力画像に周期的な濃度ムラが発生するという技術的課題もある。

【０００５】

一方、歯付きベルトを用いた駆動力伝達装置では、プーリと噛み合う歯付きベルトの歯が柔軟性に富んだゴム径の材料で製作されているため、プーリと歯付きベルトとの噛み合い振動は歯車よりも少ないと期待される。しかし、実測を行った結果は、次に示すように歯車とほとんど変わらない結果であった。

すなわち、図１９は、駆動力伝達部材としてすぐ歯ベルト及びすぐ歯歯車を用いた場合の回転ムラを示す図である。

図１９から分かるように、すぐ歯ベルトを用いても、すぐ歯歯車の回転ムラと

ほとんど変わらない結果しか得られていない。

確かに、回転ムラは歯のピッチを細かくすることにより改善されるが、あまり細かくすると負荷増加による歯飛び現象が生じ駆動不可能となるため、大きな改善は望めない。従って、すぐ歯ベルトを用いても、出力画像の濃度ムラ発生を防止することはできないことになる。

【０００６】

図２０は、カラープリンタなどの画像形成装置において濃度ムラ許容値と像担持体ドラムの回転ムラとの関係を示す。

同図において、出力画像の濃度ムラが認知可能となる像担持体ドラムの回転ムラレベルは、回転ムラの指標となる速度変動率△V0-p（％）において約０．３％であり、これ以上の速度変動率が発生すると出力画像の濃度ムラが問題となってしまう。そのため、歯車や歯付きベルトにおける噛み合い振動レベルは、この濃度ムラという観点からは非常に大きな問題となる。

すなわち、画像形成装置としての回転ムラ要求は非常に高度なレベルが要求され、はす歯ベルトを用いた場合でも歯飛び現象などすぐ歯ベルト同様に生じるため、図１９に示すすぐ歯ベルトの回転ムラレベルを許容値以下に改善するのは困難である。

【０００７】

そこで、このような技術的課題を解決するための先行技術としては、例えば複数の像担持体ドラムの外周面を夫々同量移動させる駆動力伝達装置として、駆動プーリと従動プーリとの間に無端状の平ベルトを掛け渡すことで駆動力を伝達するものが既に提案されている（例えば特開平７－３１９２５４号公報参照）。

このタイプによれば、平ベルトとプーリ（駆動プーリ及び従動プーリ）との間は摩擦力で駆動伝達されるため、平ベルトとプーリとの間で、歯車や歯付きベルトのような噛み合いにより発生する噛み合い振動は原理的に生じない。このため、歯車や歯付きベルトを用いた場合のように、周期的な濃度ムラが出力画像に発生することは有効に防止される。

【０００８】

【発明が解決しようとする課題】

しかしながら、従来この種の平ベルトを用いた駆動力伝達装置にあっては、平ベルトとプーリとの間の駆動力伝達が摩擦伝達になるため、平ベルトとプーリとの間で滑りという新たな技術的課題が生ずる。

ここで、図２１は平ベルトを用いた駆動力伝達装置における従動プーリの平均回転速度と負荷トルクとの関係を示すグラフである。

図２１に示すように、従動プーリの平均回転速度は、負荷トルクがある限界値を超えると急激に低下する。これは、従動プーリ軸（従動軸）負荷の増加に伴い定常滑り量も増加していき、負荷がある限界値以上になると平ベルトと駆動プーリあるいは従動プーリ間の滑りが急激に大きくなり、従動プーリ平均回転速度が大きく低下するためである。

【０００９】

このような状態になる従動プーリ軸の負荷量近傍で駆動を行っていると、従動プーリの速度は時間とともに不安定な状態となり、その結果、出力画像に色ずれや転写ムラが発生して正常な画像形成動作を行うことはできなくなる。最悪の場合には、画像形成装置が停止あるいは故障を引き起こすこととなる。

また、負荷トルクの限界値を向上するためには、ベルト初期張力を増やすことが効果的である。すなわち、ベルト初期張力を増やすことによりベルトをプーリに押し付ける力が大きくなり、その結果、摩擦駆動力が増加することから、負荷トルクの限界値は増加していく。

しかし、ゴムベルトや樹脂ベルトを用いた場合には、ベルト自体の剛性が低く、大きな張力を付与することは不可能である。そのため、駆動力伝達系の剛性を確保し安定した駆動力を得る目的で金属ベルトを利用することが考えられているが、金属ベルトとプーリと間の摩擦係数は、ゴムベルトや樹脂ベルトとプーリと間の摩擦係数と比較して極端に小さいため、図２１に示すように、従動プーリ軸負荷の限界値が大きく改善されることはなく、倍の張力を与えても、目標とする画像形成装置の負荷量で駆動することはできなかった。

【００１０】

また、金属ベルトを用いて負荷トルクの限界値を向上させるために、非常に大きなベルト初期張力を付与した場合には、プーリを支持する軸が撓み、各プーリ

軸のアライメントがずれ、ベルトに大きな蛇行が発生した。これにより、平ベルトがプーリに設けたベルトエッジガイドに対し大きな力で擦られるため、ベルト端部に歪みが生じ不安定な駆動となってしまった。

従って、現実の画像形成装置において想定されるような従動負荷条件の下では安定した画像形成動作が不可能になるという致命的な欠陥があり、これもまた満足すべき解決策とはなり得ない。

【００１１】

更に、プーリへのベルト巻き付け角度を大きくすることで張力によるプーリへのベルト押し付け力を大きくすることが可能になるため、プーリへのベルト巻き付け角度を増やすこともベルトの滑りに対し効果がある。

例えば図２２に示すように、複数の感光体ドラムの駆動力伝達装置として、感光体ドラム５００（５００Ｙ，５００Ｍ，５００Ｃ，５００Ｋ）と同軸に駆動用プーリ（図示せず）を設け、この駆動用プーリに平ベルト５１０を巻き付ける構成において、駆動及び従動用の張架プーリ５０１，５０２の他に、いくつかの補助張架プーリ５１１～５１５を設けることにより、感光体ドラム５００の駆動用プーリへの平ベルト５１０の巻き付け角度を大きく確保する技術が既に提案されている（例えば特開平７－３１９２５４号公報，特開平１０－１１１５８６号公報，特開平１０－１６１３８４号公報参照）。尚、図２２中、符号５０５は中間転写用あるいは用紙搬送用のベルトユニットである。

ところが、このタイプにあっては、ベルト（平ベルト５１０）を張架するためにスペースを大きくとる必要が生じたり、補助張架プーリ５１１～５１５用支持部材を設ける必要が生じ、小型・低コストの観点からすれば、このような構成は好ましいものとは言えない。

【００１２】

そこで、本発明者らは、例えばカラー画像形成装置の像担持体ドラムの駆動力伝達装置として、所謂パーフォレーションベルトを使用する態様について検討した。

図２３（ａ）（ｂ）はパーフォレーションベルトを使用した駆動力伝達装置の概要を示すものであり、パーフォレーションベルト６００（具体的には循環移動

方向に沿って所定ピッチ間隔で貫通孔６０２が配列された平ベルト６０１［孔付き平ベルト］）を駆動あるいは従動プーリ６０３に掛け渡し、このプーリ６０３の外周面には前記貫通孔６０２に対応する突起６０４を設け、平ベルト６０１の貫通孔６０２にプーリ６０３の突起６０４を嵌合させ、パーフォレーションベルト６００を循環移動させるものである。

【００１３】

このようなタイプにあっては、従来の歯車や歯付きベルトを利用して駆動力を伝達する態様に比べて、貫通孔と突起との噛み合い時のバックラッシュがなく（貫通孔と突起にクリアランスが存在していてもベルト自体がプーリに巻き付けられているため非拘束状態とはならない）、噛み合い時の振動が低減でき、出力画像に周期的な濃度ムラなどの画像欠陥が発生するのを防止することができる。

また、各プーリ６０３の突起６０４と平ベルト６０１の貫通孔６０２とが互いに嵌合することにより駆動力を伝達するため、従来の平ベルトとプーリとの摩擦により駆動力を伝達する場合に比べて、大きな負荷が加わる場合であっても平ベルトとプーリとが滑ることがなく、出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができる。

図２４はパーフォレーションベルトを用いた駆動力伝達装置における従動プーリ軸負荷と従動プーリ回転平均速度との関係を示す。

同図によれば、パーフォレーションベルト（孔付き平ベルト）による駆動力伝達を行うことにより、通常の平ベルトと比べ高い負荷が加わった状態においても、滑りによる平均速度の低下を招くことはないことが理解される。

【００１４】

また、このようなパーフォレーションベルトを使用した駆動力伝達装置を用いれば、平ベルトやプーリとして使用する材質の幅を広げることができる。つまり、従来の平ベルトとプーリとの摩擦により駆動力を伝達する場合には、必然的に摩擦係数の高い材質（例えば、樹脂）を使用する必要があり、摩擦係数の低い材質（例えば、金属）などを使用することは実質的に不可能であった。

しかし、このようなパーフォレーションベルトを使用する態様では、各プーリ６０３の突起６０４と平ベルト６０１の貫通孔６０２とが互いに嵌合することに

より駆動力を伝達するため、摩擦係数の高低に関係なく、より適切な材質を選択することができる。

【００１５】

しかし、パーフォレーションベルトを用いた駆動力伝達装置では、通常の平ベルトを用いた態様で発生する滑りを、平ベルトの貫通孔とプーリに設けた突起との噛み合いにより防止しているため、従動プーリ軸に大きな負荷トルクがかかると、貫通孔と突起との噛み合いにかかる力が大きくなり、薄いベルトでは貫通孔の歪みが増大し、貫通孔部又は突起が破壊される現象が生じる。通常、突起部には剛球が用いられており、破壊が生じるのはパーフォレーションベルトの貫通孔部である。

ここで、パーフォレーションベルトの貫通孔の破壊を防止するためには、プーリ径を大きくしベルトの引っ張り負荷を小さくすることや、ベルトの厚みを多くすること、貫通孔及びプーリに設けた突起のピッチ間隔を狭め、駆動プーリ及び従動プーリにパーフォレーションベルトが巻きかかる領域内での噛み合い数を多くすることが考えられる。

【００１６】

しかしながら、この種の駆動力伝達装置を近年のカラー画像形成装置等に適用しようとする場合には、カラー画像形成装置は近年小型化が進んできている関係上、プーリ径を劇的に大きくすることは不可能であり、また、これに伴いベルトの厚みを多くするとベルトの剛性が増し、小径のプーリにパーフォレーションベルトが巻きかからないといった技術的課題が生じてくる。

また、貫通孔や突起の間隔を狭くしていくと、各貫通孔で生じる歪みを貫通孔間で吸収できなくなり、結果として貫通孔部を破壊することになってしまう。

更に、貫通孔部の破壊は従動プーリ軸の負荷トルクによるものだけでなく、ベルト蛇行によっても生じる。

【００１７】

すなわち、パーフォレーションベルトによる駆動力伝達方式は、平ベルト同様にベルト初期張力を上げることで従動プーリ軸の負荷トルク限界値を向上することができる。そのため、ある程度の大きさでベルト張力を与えることが好ましい

が、張力を与えたことにより各プーリ軸アライメントずれが生じ、ベルトの蛇行を発生させてしまう。平ベルトはガイドによって蛇行を防止することができるが、パーフォレーションベルトによる駆動力伝達方式では、貫通孔部と突起とのクリアランスを必要以上に大きくすることは回転ムラに対し好ましくないため、パーフォレーションベルトが掛け渡されるプーリにガイドを設けることは一般に困難である。

そのため、貫通孔部は、従動プーリ軸の負荷トルクと同様、ベルト蛇行に対しても駆動中常に蛇行方向に対し力を受けることになり、負荷トルクによる回転方向での力と合わせて非常に破壊されやすい状況となってしまう。また、負荷トルクの変化によるベルト張力変化などによっても蛇行の程度が変化し、破壊現象が生じてしまう。

【００１８】

本発明は、以上の技術的課題を解決するためになされたものであって、複数の張架部材に無端状の平ベルトを掛け渡す態様において、プーリ等の張架部材と平ベルトとの間の滑りによる駆動力の伝達誤差をなくし、しかも、被駆動体に大きな負荷が係る状態であっても、駆動力を安定的に伝達することを可能とした駆動力伝達装置及びこれを用いた画像形成装置を提供するものである。

【００１９】

【課題を解決するための手段】

すなわち、本発明は、図１（ａ）に示すように、一若しくは複数の無端状平ベルト１を複数の張架部材２（例えば２ａ～２ｄ）に掛け渡すことで駆動力を伝達する駆動力伝達装置において、平ベルト１の少なくとも一つには平ベルト１の進行方向に沿って複数列の貫通孔３を設け、当該平ベルト１が掛け渡される張架部材２の少なくとも一つには平ベルト１の貫通孔３が嵌合する突起４を当該張架部材２の回転方向に沿って複数列設けたことを特徴とするものである。

そして、図１（ａ）においては、例えば一つの張架部材２ａに図示外の駆動源からの駆動力が伝達されると、この張架部材２ａを介して平ベルト１に駆動力が伝達され、この平ベルト１を介して例えば張架部材２ｂ，２ｃと同軸に設けられた被駆動体（図示せず）に駆動力が伝達される。

【００２０】

このような技術的手段において、無端状平ベルト１としては単一のものに限られず、複数のものを用いる態様であってもよい。

また、張架部材２は平ベルト１を張架するものであればよく、プーリ、ロールなど広く含む。

更に、安定的に駆動力を伝達する観点からは、駆動力伝達装置を構成する各部材の剛性は高いことが好ましい。従って、上記平ベルト１、張架部材２が剛性の高い材質、例えば金属により構成されることが好ましく、金属の種類としては耐久性などの観点からステンレスが好ましい。

更にまた、平ベルト１は進行方向に沿って貫通孔３を配列したものであり、各貫通孔３は、回転する張架部材２に設けられた突起４に嵌合するものであるため、平ベルト１の進行方向に沿って所定ピッチ間隔に設けられる。

そして、突起４と貫通孔３との形状は任意であるが、両者の嵌合性を考慮すると、一般的には突起４の形状は略半球であり、貫通孔３は円形のものを採用することが好ましい。

【００２１】

特に、本発明においては、平ベルト１の貫通孔３は平ベルト１の進行方向に沿って複数列設けられていればよい。

ここで、「平ベルト１の進行方向に沿って複数列設ける」とは、平ベルト１の進行方向に直交する幅方向に対して複数列配列することを意味し、その配列方法については任意である。

このように、貫通孔３を複数列設けるようにすれば、被駆動体に連結される張架部材２（例えば２ｂ，２ｃ）の軸に大きな負荷トルクがかかったとしても、複数列の貫通孔３部で力を分散して受け止めることができ、貫通孔３部での破壊を有効に防止することができる。

【００２２】

また、貫通孔３の好ましい配列については、平ベルト１の進行方向に直交する幅方向に対して隣接する貫通孔３の各々は、平ベルト１の進行方向に対して相互に重複しない位置に配置されていることが好ましい。

このようにすれば、貫通孔３間のベルト剛性を確保することで、ベルト初期張力として大きな張力を与えても、ベルト蛇行による貫通孔３部の破壊を有効に防止できる。

【００２３】

更に、上述した駆動力伝達装置に係る発明を画像形成装置に適用すると、以下のようになる。

すなわち、本発明に係る画像形成装置は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図１（ａ）に示すように、駆動源と像担持体との間に配設される複数の張架部材２と、この複数の張架部材２に掛け渡される一若しくは複数の無端状平ベルト１とを備え、平ベルト１の少なくとも一つには進行方向に沿って複数列の貫通孔３を設け、平ベルト１が掛け渡される張架部材２の少なくとも一つには平ベルト１の貫通孔３が嵌合する突起４を当該張架部材２の回転方向に沿って複数列設けたものである。

ここで、像担持体としては、感光体の他、中間転写体や用紙等のシート搬送体も含まれ、これらの形態としては、ドラム状（円筒状）のものの他、無端ベルト状のものも含まれる。

【００２４】

このような画像形成装置によれば、上述の駆動力伝達装置を画像形成装置として適用する場合には、従来の歯車や歯付きベルトを利用して駆動力を伝達する態様に比べて、噛み合いの振動がなく、出力画像に周期的な濃度ムラなどの画像欠陥が発生するのを防止することができる。

また、各張架部材２の突起４と平ベルト１の貫通孔３とが互いに嵌合することにより駆動力を伝達するため、従来の平ベルトとプーリとの摩擦により駆動力を伝達する場合に比べて、大きな負荷が加わる場合であっても平ベルトとプーリとが滑ることがなく、かつ、より大きな負荷が加わった場合であっても、貫通孔３部が破壊することなく、出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができ、安定した画像形成動作を行わせることが可能となる

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【００２５】

更に、省エネルギやコスト軽減の観点から、像担持体のみならず、転写ロール、帯電ロールなどの像担持体と接触して従動回転する回転体をも含めて単一の駆動源で回転駆動させる場合や、これらの像担持体や他の回転体の軸受が部品点数軽減のためにベアリング等の転がり軸受ではなくすべり軸受が採用される場合に、像担持体の回転負荷は増大する傾向にある。従って、このような画像形成装置に本発明を適用することが好ましい。

【００２６】

また、画像形成装置の中には複数系統の像担持体を備えるものが存在する。

ここで、回転負荷の大きい場合でも平ベルト１とプーリ等の張架部材２との間で滑りが生ぜず、平ベルト１の貫通孔３部の破壊も防止でき、出力画像に色ずれや転写ムラなどの画像欠陥が発生しないという本発明の利点を生かすためには、より回転負荷の大きい系統の像担持体に本発明を適用することが好ましい。

このような場合、本発明は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置として、図１（ａ）に示す駆動力伝達装置を用いるようにすればよい。

本態様において、「回転負荷が最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置」とは、ある系統の像担持体が複数あり、各像担持体への駆動力伝達系が並列的に設けられるものであれば対象となる像担持体に対する駆動力伝達系を指す。また、ある系統の像担持体が複数あり、各像担持体への駆動伝達系が直列的に設けられるものであれば回転負荷の最も大きい像担持体を含む複数の像担持体への駆動力伝達系全体を指す。

【００２７】

更に、単一の駆動源により複数系統の像担持体などを回転駆動させる場合に、一つの系統の像担持体へ加わる外乱（例えば、クリーニング装置、転写装置の接

触や離間、記録シート上への乗り上げや乗り下げなど）が、他の像担持体へ影響を与えてしまう虞れがある。

このような場合、本発明は、二系統の像担持体を備えた画像形成装置において、駆動力伝達装置としては、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えるようにすればよい。

このように画像形成装置を構成することにより、第一系統の像担持体へ何らかの外乱が加わり、その外乱が第一平ベルトを介して駆動源に伝達されても、駆動源はその特性［具体的には、駆動源は、自ら駆動トルク（第一の平ベルトと第二の平ベルトに掛かる負荷トルクの合計）を発生させ回転しており、従動プーリが直接平ベルトから外乱（トルク変動）を受けるより、ＤＣ的に大きなトルク発生源を通過させる方が、駆動源の保持力が利くため外乱に対する影響が小さい］により当該外乱を打ち消し、第二平ベルトを介して第二系統の像担持体へその外乱が伝達されることはない。逆に、第二系統の像担持体へ外乱が加わる場合も同様である。

【００２８】

ここで、二系統の像担持体の関係としては、例えば、①第一系統の像担持体は記録シートが直接接触するものであり、第二系統の像担持体は直接接触しないもの、②第一系統の像担持体表面に保持されるトナー像と第二系統の像担持体表面に保持されるトナー像との色が相異なるもの、③第一系統の像担持体にはクリーニング装置が当接離間しないが、第二系統の像担持体には当接離間するもの、④第一系統の像担持体には転写装置が当接離間しないが、第二系統の像担持体には当接離間するもの、⑤これら第一及び第二系統の像担持体にクリーニング装置や転写装置が当接離間するタイミングが夫々異なるものなどの態様が挙げられる。

【００２９】

また、本発明に係る駆動力伝達装置の別の態様は、図１（ｂ）に示すように、一若しくは複数の無端状平ベルト１を複数の張架部材２（例えば２ａ～２ｃ）に掛け渡すことで駆動力を伝達する駆動力伝達装置において、駆動力が伝達せしめられる張架部材２の少なくとも一つ（例えば２ａ）に当該張架部材２ａの回転軸

に対して同軸で且つ自由回転可能な自由回転体５を設け、この自由回転体５が設けられた張架部材２（例えば２ａ）とは異なって隣接し合う張架部材２（例えば２ｂ，２ｃ）に対し平ベルト１を前記自由回転体５を介して掛け渡すようにしたことを特徴とするものである。

【００３０】

そして、図１（ｂ）においては、張架部材２（例えば２ａ）に駆動力が伝達せしめられると、この張架部材２ａを介して平ベルト１に駆動力が伝達され、この平ベルト１を介して例えば張架部材２ｂ，２ｃと同軸に設けられる被駆動体（図示せず）に駆動力が伝達される。

このとき、平ベルト１は張架部材２ｂ，２ｃに対し自由回転体５を介して掛け渡されているため、平ベルト１の張架部材２ｂ，２ｃへの巻き付け角度は充分に大きく確保され、平ベルト１と被駆動体が連結された張架部材２ｂ，２ｃとの間の摩擦抵抗は充分に大きなものになり、平ベルト１からの駆動力が張架部材２ｂ，２ｃに確実に伝達される。

一方、自由回転体５は張架部材２（例えば２ａ）の回転軸に同軸且つ自由回転可能に設けられるため、自由回転体５の設置スペースを独自に確保する必要性はない。

これにより、従来のような余計な補助張架プーリを支持するための部材や、スペースを必要とすることなく、被駆動体が連結される張架部材２（例えば２ｂ，２ｃ）に対する平ベルト１の巻き付け角度を充分に大きく設定することが可能になる。

【００３１】

このような技術的手段において、平ベルト１は単数に限定されるものではなく複数でもよいし、また、張架部材２にはプーリ、ロール等を広く含む。

ここで、「駆動力が伝達せしめられる張架部材２（例えば２ａ）」とは、駆動源に直結されていてもよいし、あるいは、別の駆動伝達系にて駆動されるものでもよい。

更に、「自由回転体５」は、駆動力が伝達せしめられる張架部材２（例えば２ａ）の回転軸に対して同軸で且つ自由回転可能であることを要し、ベアリング、

カラーなどを広く含む。

【００３２】

また、図１（ｂ）の態様では、平ベルト１は通常のものをも含むが、平ベルト１と張架部材２との間の滑りを有効に回避するという観点からすれば、平ベルト１の少なくとも一つには進行方向に沿って一若しくは複数列の貫通孔（図示せず）を設け、当該平ベルト１が掛け渡される張架部材２の少なくとも一つには平ベルト１の貫通孔が嵌合する突起（図示せず）を設ける態様が好ましい。

このような態様によれば、平ベルト１の張架部材２への巻き付け角度を大きくできることから、突起が嵌合する貫通孔部へ作用する力を分散でき、貫通孔部の破壊を有効に防止することができる。

【００３３】

更に、自由回転体５が張架部材２の回転軸方向に移動すると、この自由回転体５に掛け渡された平ベルト１が蛇行することになるため、平ベルト１の蛇行を有効に防止するという観点からすれば、自由回転体５の軸方向位置を規制することが好ましい。

この場合、自由回転体５は張架部材２の回転軸の軸方向に対し位置規制部材（図示せず）にて位置規制されるようになっていればよい。

更にまた、自由回転体５自体を軸方向に位置規制したとしても、自由回転体５に掛け渡される平ベルト１自体が蛇行する懸念があるが、これを有効に防止するという観点からすれば、自由回転体５は、掛け渡される平ベルト１の進行方向に直交する幅方向に対する位置を規制する位置規制部を具備していることが好ましい。

ここでいう「位置規制部」には、平ベルト１が孔付きであればその貫通孔に嵌合する突起や、平ベルト１の蛇行を防止する規制壁など広く含む。

【００３４】

更に、上述した駆動力伝達装置に係る発明を画像形成装置に適用すると、以下のようになる。

すなわち、本発明に係る画像形成装置は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を

像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図１（ｂ）に示すように、駆動源と像担持体との間に配設される複数の張架部材２（例えば２ａ～２ｃ）と、この複数の張架部材２に掛け渡される一若しくは複数の無端状平ベルト１とを備え、駆動力が伝達せしめられる張架部材２の少なくとも一つ（例えば２ａ）に当該張架部材２ａの回転軸に対して同軸で且つ自由回転可能な自由回転体５を設け、この自由回転体５が設けられた張架部材２ａとは異なって隣接し合う張架部材２（例えば２ｂ，２ｃ）に対し平ベルト１を前記自由回転体５を介して掛け渡すようにしたものである。

【００３５】

このような画像形成装置によれば、図１（ｂ）に示す駆動力伝達装置は、レイアウトスペースを不必要に拡大することなく、複数の張架部材２への平ベルト１の巻き付け角度を大きく確保でき、駆動力の伝達誤差を低減できるため、小型化、低コストの要請を見たしながら、画像形成装置として出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができ、安定した画像形成動作を行わせることが可能となる。

更に、省エネルギやコスト軽減の観点から、像担持体のみならず、転写ロール、帯電ロールなどの像担持体と接触して従動回転する回転体をも含めて単一の駆動源で回転駆動させる場合や、これらの像担持体や他の回転体の軸受が部品点数軽減のためにベアリング等の転がり軸受ではなくすべり軸受が採用される場合に、像担持体の回転負荷は増大する傾向にある。従って、このような画像形成装置に本発明を適用することが好ましい。

【００３６】

また、画像形成装置の中には複数系統の像担持体を備えるものが存在するが、図１（ａ）に示す駆動力伝達装置を組み込んだ画像形成装置と同様に、回転負荷の大きい系統の像担持体に本発明を適用することが好ましい。

このような場合、本発明は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達

する駆動力伝達装置として、図１（ｂ）に示す駆動力伝達装置を用いるようにすればよい。

更に、単一の駆動源により二系統の像担持体を回転駆動させる場合には、本発明は、二系統の像担持体を備えた画像形成装置において、駆動力伝達装置としては、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えるようにすればよい。

【００３７】

【発明の実施の形態】

以下、添付図面に示す実施の形態に基づいて本発明を詳細に説明する。

◎実施の形態１

図２は、本発明を適用した複写機（画像形成装置）８０の実施の形態１を示す断面概略図である。

同図において、この複写機８０の構成を、画像入力系、画像形成系、シート搬送系に分けてそれぞれ説明する。

画像入力系は、原稿が載置される原稿載置台７０、この原稿載置台７０上の原稿を読み取る原稿読取装置７１、この原稿読取装置７１にて読み取られた画像情報を処理する画像処理装置７２を備えている。

画像形成系は、ブラック、イエロ、マゼンタ、シアンの各色に対応する画像形成ステーション１０（具体的には１０Ｋ，１０Ｙ，１０Ｍ，１０Ｃ：図中点線で囲む部分）、この画像形成ステーション１０に画像処理装置７２からの画像データに基づいて露光する露光装置１３（具体的には１３Ｋ～１３Ｃ）、各画像形成ステーション１０にて形成された画像が順次転写保持せしめられる二つの第一中間転写ドラム３１（具体的には３１ａ，３１ｂ）、及び、一つの第二中間転写ドラム３２を備えている。

【００３８】

ここで、各画像形成ステーション１０には、感光体ドラム１１（具体的には１１Ｋ～１１Ｃ）、感光体ドラム１１を帯電する帯電装置１２（具体的には１２Ｋ～１２Ｃ）、帯電された感光体ドラム１１上に露光装置１３により書き込まれた

静電潜像を各色トナーにて現像する現像装置１４（具体的には１４Ｋ～１４Ｃ）などの電子写真用デバイスが具備されている。

尚、各感光体ドラム１１（１１Ｋ～１１Ｃ）と第一中間転写ドラム３１ａ，３１ｂとが対峙する部分には図示しない（一次）転写装置が、第一中間転写ドラム３１ａ，３１ｂと第二中間転写ドラム３２とが対峙する部分には図示しない（二次）転写装置が夫々設けられている。

【００３９】

更に、シート搬送系は、用紙等の記録シートが積載されるシートトレイ４０、シートトレイ４０内の記録シートを一枚ずつ繰り出すピックアップロール４１、繰り出された記録シートを位置決めするレジストロール４２、第二中間転写ドラム３２上の画像を記録シートに転写する（三次）転写ロール４３、記録シート上に転写された画像を定着する定着ロール４４、排出された記録シートを収容する排出トレイ４５などを備えている。

【００４０】

次に、このような複写機８０の基本的なフルカラー複写動作について説明する。

まず、ユーザが原稿載置台７０の上に読取原稿を載せ、図示しないユーザインターフェイスにより複写指示を行うと、画像読取装置７１が走査しつつ原稿を光学的に読み取り、電気信号（画像データＩ）に変換する。その画像データＩは、画像処理主装置７２において、ブラック、イエロ、マゼンタ、シアンの各色に色分解され、それら各色の画像データＩ（ＩＫ，ＩＹ，ＩＭ，ＩＣ）に、マーキングデバイス／プロセスの特性を考慮した所定の重み係数を付与する等の画像処理が施される。

【００４１】

一方、各画像形成ステーション１０内の感光体ドラム１１は、後述するベルト駆動装置１００（図３，図４参照）により図中矢印の方向へ回転駆動されている。この感光体ドラム１１の表面は、帯電装置１２により一様な所定電位に帯電される。そして、各露光装置１３（１３Ｋ～１３Ｃ）がそれぞれ画像データＩ（ＩＫ～ＩＣ）に対応した露光光を所定タイミングで各感光体ドラム１１（１１Ｋ～

１１Ｃ）表面に照射することにより、各感光体ドラム１１（１１Ｋ～１１Ｃ）表面には電位差による静電潜像が形成される。その静電潜像は、各現像装置１４（１４Ｋ～１４Ｃ）によりトナーが静電的に付着され、トナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）となる。

【００４２】

他方、第一中間転写ドラム３１ａ，３１ｂ及び第二中間転写ドラム３２は、後述するベルト駆動装置１００（図３，図４参照）により図中矢印の方向へ回転駆動されている。そして、このトナー画像Ｔ（Ｋ，Ｙ）は、図示しない一次転写装置により感光体ドラム１１（１１Ｋ，１１Ｙ）から第一中間転写ドラム３１ａへ、トナー画像Ｔ（Ｍ，Ｃ）は、感光体ドラム１１（１１Ｍ，１１Ｃ）から第一中間転写体ドラム３１ｂへと静電的に（一次）転写される。この際、トナー画像Ｔ（Ｋ，Ｙ）は第一中間転写ドラム３１ａ表面で重ね合わされ、トナー画像Ｔ（Ｍ，Ｃ）は第一中間転写ドラム３１ｂ表面で重ね合わされる。

【００４３】

更に、第一中間転写ドラム３１ａ上で重ね合わされたトナー画像Ｔ（ＫＹ）は、図示しない二次転写装置により第二中間転写ドラム３２へ、同じく第一中間転写ドラム３１ｂ上で重ね合わされたトナー画像Ｔ（ＭＣ）も第二中間転写ドラム３０へと静電的に（二次）転写される。この際、トナー画像Ｔ（ＫＹ）とトナー画像Ｔ（ＭＣ）とは第二中間転写ドラム３２表面で重ね合わされ、フルカラーのトナー画像Ｔ（ＫＹＭＣ）が形成される。

このように、トナー画像Ｔ（ＫＹＭＣ）が形成される間、シート搬送系においては、シートトレイ４０内の記録シートＳがピックアップロール４１により一枚取り出され、レジストロール４２へと搬送される。例えばレジストロール４２が停止状態から所定タイミングまで回転を開始することにより、第二中間転写ドラム３２上のフルカラートナー画像Ｔ（ＫＹＭＣ）が転写ロール４３とのニップ部に達するタイミングと、記録シートＳがそのニップ部分に達するタイミングとを一致させ、転写ロール４３により第二中間転写ドラム３２上のフルカラートナー画像Ｔ（ＫＹＭＣ）が記録シートＳに静電的に転写される。

その後、表面にフルカラートナー画像Ｔ（ＫＹＭＣ）を静電的に保持する記録

シートＳは、定着ロール４４のニップ部分を通過する際に、各定着ロール４４からの熱と圧力とその作用によりそのフルカラートナー画像Ｔ（ＫＹＭＣ）を表面に定着させ、複写機８０外部の排出トレイ４５へと排出される。

このような複写工程を一サイクルとし、これを連続的に行うことにより、次々にフルカラー画像を複写することができる。

【００４４】

図３は、この複写機８０を駆動するベルト駆動装置１００を示す斜視図であり、図２の背面側から眺めた構成を示すものである。尚、図４（ａ）は図３のベルト駆動装置１００の正面説明図、（ｂ）はその平面説明図である。

同図において、ベルト駆動装置１００は、各感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、及び、第二中間転写ドラム３２を駆動するものであり、二つの平ベルト１０１，１０２と、これらの平ベルト１０１，１０２が張架せしめられる各種張架部材とを備えている。

ここで、張架部材としては、各感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、及び、第二中間転写ドラム３２のそれぞれ軸方向一端に取り付けられた従動プーリ１１１～１１７と、各平ベルト１０１，１０２の取り回しを行うための張架プーリ１２１，１２２とがある。

尚、本実施の形態では、第二中間転写ドラム３２に取り付けられた従動プーリ１１７は第一、第二の平ベルト１０１，１０２がそれぞれ掛け渡される二段のベルト掛け渡し面を有している。

【００４５】

そして、第一の平ベルト１０１は、張架プーリ１２１と、各感光体ドラム１１（１１Ｋ～１１Ｃ）の軸に取り付けられた従動プーリ１１１～１１４と、第二中間転写体ドラム３２の軸に取り付けた従動プーリ１１７とに掛け渡されている。

一方、第二の平ベルト１０２は、張架プーリ１２２と、第一中間転写ドラム３１ａ，３１ｂの軸に取り付けた従動プーリ１１５，１１６と、第二中間転写体ドラム３２の軸に取り付けた従動プーリ１１７とに掛け渡されている。

尚、各プーリ１１１～１１７，１２１，１２２に設けられているプーリ軸（図示せず）は、複写機８０の側面に設けられる各すべり軸受により軸受され、各プ

ーリは回転自在に構成されている。

【００４６】

ここで、図示外の駆動モータ（駆動源）からの出力をどの軸に与えるかであるが、平ベルトとプーリの巻き付け角度が大きいプーリ軸に駆動モータからの駆動を入力させる構成をとることが望ましい。

本実施の形態においては、例えば第二中間転写ドラム３２の軸へ駆動モータからの駆動力を入力するように設定することができるが、他のプーリ軸へ駆動モータからの駆動力を入力する構成としてもよい。

また、平ベルト１０１，１０２の材質としては樹脂製のものを採用することもできるが、耐久性や加工精度等の面からステンレス、ニッケル、チタン等の金属を使用することが好ましく、価格、耐久性、機械的強度の観点からステンレスを使用することが特に好ましい。

同様に、各プーリの材質としては樹脂製のものを採用することもできるが、耐久性や加工精度等の面からステンレス、アルミニウム、炭素鋼等の金属を使用することが好ましい。特に、金属製のプーリは樹脂製のプーリに比べて一般的に慣性モーメントが大きくなるため、画像形成装置において出力画像の画像欠陥を招くとして問題視されている噛み合い振動などの高周波振動の減衰効果が期待でき、その観点からもプーリの材質としては金属が好ましい。また、金属のうちでは価格、耐久性、機械的強度の観点からステンレスを使用することが特に好ましい。

【００４７】

図５は、平ベルトとプーリとの構成をより詳細に説明するものである。

ここでは、図２の中間転写ドラム駆動に用いる平ベルト１０１，１０２、及び、各プーリ１１０（１１１～１１７，１２１，１２２）を例に挙げて説明する。

図２に示した第一中間転写ドラム３１ａ，３１ｂは、図示外のクリーナが当接しており、他のドラムと比較して大きな負荷が与えられている。そのため、本実施の形態では、第一、第二の平ベルト１０１，１０２には、進行方向に沿って複数列（本例では３列）の貫通孔１３０が設けられ、また、各プーリ１１０の全部若しくは一部（本例では全部の例が示されている）には平ベルト１０１，１０２

の貫通孔１３０に対応して複数列（本例では３列）の突起１４０が設けられており、平ベルト１０１，１０２の貫通孔１３０にプーリ１１０の突起１４０を嵌合させることで、平ベルト１０１，１０２の安定な駆動が実現されるようになっている。

本実施の形態で、貫通孔１３０としては例えば円形孔が用いられ、一方、突起１４０としては半球状突起が用いられる。

【００４８】

図５（ａ）（ｂ）（ｃ）に示す本実施の形態において、平ベルト１０１，１０２の全ての列の貫通孔１３０ピッチは同一間隔に設定されているが、特に合わせる必要はなく、各列にて間隔を変更することも可能である。また、３列の貫通孔１３０のうち、中央列の貫通孔１３０ｂピッチｐは、両側列の貫通孔１３０ａ，１３０ｃピッチｐと同一間隔であるが、位相θを１８０度ずらして設定されている。

これは、後述するように、ベルト蛇行による貫通孔部の破壊を防止する目的で故意に変えているものである。

また、本実施の形態において、平ベルト１０１，１０２には複数列の貫通孔１３０が設けられているが、プーリ１１０に設ける突起１４０は前記貫通孔１３０に対応して複数列設けられているが、必ずしも全ての貫通孔１３０に対応させて設ける必要はなく、少なくとも負荷の最も大きいプーリ１１０に設けるようにすればよい。

このため、負荷が小さいプーリ１１０には、複数列全てに嵌合させる必要はなく、３列中の１列を嵌合するようにすることも可能であるし、突起１４０のピッチを貫通穴ピッチの整数倍とすることも可能である。よって、複数列の貫通孔１３０を設けた平ベルト１０１，１０２と、この平ベルト１０１，１０２が巻き付く幾つかのプーリ１１０の各々の嵌合仕様は、使用するケース毎に自由に設計することができる。

【００４９】

図６（ａ），（ｂ）は、本実施の形態における構成の負荷に対する効果の概要を、図６（ｃ），（ｄ）はベルト蛇行に対する効果の概要をそれぞれより詳細に

説明するものである。

図６は矢印Ａ方向に循環移動するパーフォレーションベルト（貫通孔付き平ベルト）と、このベルトに設けた貫通孔と嵌合するプーリに設けた突起とを表している。

図６（ａ）は、貫通孔１３０’が１列孔タイプの比較の態様（平ベルト１０１’，１０２’）における駆動状態を示しており、高負荷の場合には、図示するように貫通孔１３０’部の循環方向と反対側で駆動を行うことになり、突起１４０’と噛み合う部分に歪みが生じる。この歪みがある大きさ以上になるとベルトの貫通孔１３０’部は破壊され、駆動が不安定になる。

この歪みの影響を低減し、安定な駆動を行わせるため、本実施の形態では、図６（ｂ）に示すような循環方向に対し、平ベルト１０１，１０２に複数列の貫通孔１３０を設けた構成としている。これにより、高負荷のプーリ１１０を駆動する際に生じる１個あたりの貫通孔１３０部の歪みを低減し、安定な駆動伝達を行うことが可能となる。

【００５０】

図６（ｃ）は、本実施の形態において、平ベルト１０１，１０２の複数列の貫通孔１３０を同位相で配列した変形形態を示す。

この場合、負荷に対する効果は、図６（ｂ）と同様で、貫通孔１３０部の１個当たりの歪みを低減することが可能である。しかし、ベルト蛇行が発生するような状況では、蛇行方向に対する貫通孔１３０部のピッチが細かくなりすぎるため、歪みを吸収する領域がなくなり、貫通孔１３０部の破壊を招きやすい。

そのため、ベルト蛇行方向を考える場合には、本実施の形態のように、図６（ｄ）のような構成とすることが望ましい。

このため、ベルト幅が十分広く取れる場合では、複数列設けた蛇行方向の貫通孔ピッチも大きくとれるため、図６（ｃ）の構成でも問題はないが、画像形成装置などの小型化が要求される場合には、図６（ｄ）の構成を取る方が望ましい。よって、本実施の形態では、図４（ｂ），（ｄ）の構成をとることにより、安定な駆動を実現することが可能となる。

【００５１】

従って、本実施の形態によれば、平ベルト１０１，１０２の貫通孔１３０部で破壊が起こる懸念はなく、駆動モータからの駆動力が感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、及び、第二中間転写ドラム３２に確実に伝達される。

このことは、後述する実施例１にて裏付けられる。

【００５２】

特に、現在、鋭意開発が進められているカラー画像形成装置の分野では、消費電力やコスト低減の必要性から、感光体ドラムのみならず中間転写ドラムや中間転写ベルト、さらには転写ロールや帯電ロールまで単一の駆動モータで駆動する方式が追求されており、画像形成動作を実施するために駆動力伝達部材が打ち勝たなければならない負荷トルクは次第に増大する傾向にある。

更に、部品コスト削減のために、各像担持体ドラムの回転軸を支持する軸受が、従来から使用されていた転がり軸受から、すべり軸受に変更されるケースが多く、この軸受の変更によっても負荷トルクの増大に拍車がかかっているという状況にある。

このような要請下においても、本実施の形態は極めて有効である。このことは、以後の実施の形態においても同様である。

【００５３】

尚、本実施の形態では、ベルト駆動装置１００としては、二つの平ベルト１０１，１０２と、これらを掛け渡すプーリ１１０（１１１～１１７，１２１，１２２）とからなるものが用いられているが、これに限られるものではなく、例えば図７に示すように、一つの平ベルト１０３と、これを掛け渡すプーリ（従動プーリ１１１～１１７，張架プーリ１２１）とを備え、例えば第二中間転写ドラム３２に連結される従動プーリに駆動モータからの駆動力を入力し、各プーリ１１０に掛け渡された一つの平ベルト１０３を介して各プーリ１１０に駆動力を伝達し、感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、第二中間転写ドラム３２を駆動するようにしてもよい。

【００５４】

◎実施の形態２

図８は、本発明を適用した実施の形態２に係る複写機（画像形成装置）９０の断面概略図である。

同図において、この複写機９０の構成を、画像入力系、画像形成系、シート搬送系に分けてそれぞれ説明する。

画像入力系は、原稿載置台７０、原稿読取装置７１、画像処理装置７２を備えている。

また、画像形成系は、ブラック、イエロ、マゼンタ、シアンの各色に対応する画像形成ステーション１０（具体的には１０Ｋ，１０Ｙ，１０Ｍ，１０Ｃ：図中点線で囲む部分）、及び、この画像形成ステーション１０に画像処理装置７２からの画像データに基づいて露光する露光装置１３（具体的には１３Ｋ～１３Ｃ）を備えている。

ここで、画像形成ステーション１０（１０Ｋ～１０Ｃ）には、感光体ドラム１１（具体的には１１Ｋ～１１Ｃ）、感光体ドラム１１を帯電する帯電装置１２（具体的には１２Ｋ～１２Ｃ）、帯電された感光体ドラム１１上に露光装置１３にて書き込まれた静電潜像を各色トナーにて現像する現像装置１４（具体的には１４Ｋ～１４Ｃ）、感光体ドラム１１上の残留トナーを清掃するドラムクリーナ１５（具体的には１５Ｋ～１５Ｃ）、及び、感光体ドラム１１上の画像を記録シートＳに転写する転写ロール２２（具体的には２２Ｋ～２２Ｃ）などの電子写真用デバイスが具備されている。

特に、本実施の形態では、感光体ドラム１１（１１Ｋ～１１Ｃ）は各ベルト駆動装置５０（具体的には５０Ｋ～５０Ｃ）により駆動されるようになっているが、各ベルト駆動装置５０（５０Ｋ～５０Ｃ）は単一の駆動モータからの駆動力を図示外の全体ベルト駆動装置を介して各ベルト駆動装置５０の駆動力伝達軸に取り込むようになっている。

【００５５】

更に、シート搬送系は、レジストロール４２の後段に、各画像形成ステーション１０（１０Ｋ～１０Ｃ）に対応して記録シートＳを搬送するシート搬送ベルト２０を有し、このシート搬送ベルト２０の後段に定着ロール４４などを備えている。

そして、本実施の形態では、シート搬送ベルト２０は、少なくとも駆動ロール２４ａが含まれる複数の張架ロール２４（２４ａ～２４ｅ）に掛け渡されており、このシート搬送ベルト２０の周囲には、ベルトクリーナ２６、ベルト除電装置２７、シート搬送ベルト２０に記録シートＳを吸着保持するための吸着用帯電装置２８、及び、シート搬送ベルト２０から記録シートＳを剥離するための剥離用帯電装置２９が設けられている。

【００５６】

次に、このような複写機９０の基本的なフルカラー複写動作について説明する。

まず、ユーザが原稿載置台７０の上に読み取り原稿を載せ、図示しないユーザインターフェイスにより複写指示を行うと、画像読取装置７１が走査しつつ原稿を光学的に読み取り、電気信号（画像データＩ）に変換する。その画像データＩは、画像処理装置７２において、ブラック、イエロ、マゼンタ、シアンの各色に色分解され、それら各色の画像データＩ（ＩＫ，ＩＹ，ＩＭ，ＩＣ）に、マーキングデバイス／プロセスの特性を考慮した所定の重み係数を付与する等の画像処理が施される。

【００５７】

一方、各画像形成ステーション１０内の感光体ドラム１１は、ベルト駆動装置５０（５０Ｋ～５０Ｃ）により図中矢印の方向へ回転駆動されている。この感光体ドラム１１（１１Ｋ～１１Ｃ）の表面は、帯電装置１２（１２Ｋ～１２Ｃ）により一様な所定電位に帯電される。そして、各露光装置１３（１３Ｋ～１３Ｃ）がそれぞれ画像データＩ（ＩＫ～ＩＣ）に対応した露光光を所定タイミングで各感光体ドラム１１（１１Ｋ～１１Ｃ）表面に照射することにより、各感光体ドラム１１表面には電位差による静電潜像が形成される。その静電潜像は、各現像装置１４（１４Ｋ～１４Ｃ）によりトナーが静電的に付着され、トナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）となる。

【００５８】

このように、トナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）が形成される間、シート搬送系においては、図示外のシートトレイ内の記録シートＳが図示外のピックアップロ

ールにより一枚取り出され、レジストロール４２へと搬送される。例えばレジストロール４２が停止状態から所定タイミングで回転を開始することにより、図示外の駆動装置により図中矢印の方向へ回転駆動されているシート搬送ベルト２０へ記録シートＳが引き渡される。

尚、レジストロール４２からシート搬送ベルト２０へと記録シートＳが引き渡される際に、吸着用帯電装置２８により記録シートＳへシート搬送ベルト２０に吸着するような電荷が与えられる。

【００５９】

そして、この感光体ドラム１１（１１Ｋ～１１Ｃ）上のトナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）は、転写ロール２２（２２Ｋ～２２Ｃ）により各感光体ドラム１１（１１Ｋ～１１Ｃ）からシート搬送ベルト２０上の記録シートＳへと順次静電的に転写される。この際、記録シートＳにはまずトナー画像Ｔ（Ｋ）が一次転写され、トナー画像Ｔ（Ｋ）の上にトナー画像Ｔ（Ｙ）が、その上にトナー画像Ｔ（Ｍ）が、更にその上にトナー画像Ｔ（Ｃ）が順に重ね合わされ、結果としてフルカラーのトナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）が形成される。

尚、一次転写後に各感光体ドラム１１（１１Ｋ～１１Ｃ）表面に残存する一部のトナーなどの異物は、ドラムクリーナ１５（１５Ｋ～１５Ｃ）により除去される。また、シート搬送ベルト２０表面に残存するトナーなどの異物は、ベルトクリーナ２６により除去される。更に、シート搬送ベルト２０に残存する電位履歴は、ベルト除電装置２７により除去される。

【００６０】

その後、表面にフルカラートナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）を静電的に保持する記録シートＳは、定着ロール４４のニップ部分を通過する際に、各定着ロール４４からの熱と圧力との作用によりそのフルカラートナー画像Ｔ（Ｋ，Ｙ，Ｍ，Ｃ）を表面に定着させ、複写機９０外部へと排出される。

ここで、シート搬送ベルト２０から定着ロール４４へと記録シートＳが引き渡される際に、剥離用帯電装置２９により記録シートＳへシート搬送ベルト２０から剥がれるような電荷が与えられる。

このような複写工程を一サイクルとし、これを連続的に行うことにより、次々

にフルカラー画像を複写することができる。

【００６１】

このような複写機９０の各感光体ドラム１１（１１Ｋ～１１Ｃ）の駆動に使用される各ベルト駆動装置５０（５０Ｋ～５０Ｃ）及び全体ベルト駆動装置について、実施の形態１のように、複数列の孔付き平ベルトと突起付きプーリとを適用するようにすれば、実施の形態１と同様な作用、効果を奏することができる。

また、シート搬送ベルト２０の駆動装置についても、実施の形態１と同様な態様のベルト駆動装置を適用することもでき、その両方の駆動に実施の形態１と同様なベルト駆動装置を適用するようにしてもよい。

【００６２】

◎実施の形態３

実施の形態１，２はいずれも画像形成装置に適用されるベルト駆動装置を示したものであるが、本実施の形態は、広く被駆動体を駆動するベルト駆動装置の代表的な態様を示す。

図９（ａ）～（ｄ）に係るベルト駆動装置１００は、一つの平ベルト１０５と、この平ベルト１０５が掛け渡される張架部材とを備え、張架部材としては、いずれも駆動モータ（図示せず）からの駆動力が伝達される駆動プーリ１５１と、この駆動プーリ１５１に隣接して設けられ且つ被駆動体（図示せず）が連結される例えば二つの従動プーリ１５２，１５３と、平ベルト１０５を取り回すための張架プーリ１５４とを備えている。

【００６３】

本実施の形態において、平ベルト１０５には、平ベルト１０５の進行方向に沿って複数列（本例では３列）の貫通孔１３０を実施の形態１のように開設され、プーリ１５１～１５４の全部若しくは一部（本例では、例えば駆動プーリ１５１，従動プーリ１５２，１５３）には前記貫通孔１３０に対応して複数列の突起１４０が設けられ、平ベルト１０５の貫通孔１３０にプーリ１５１～１５３の突起１４０を嵌合させることで、平ベルト１０５の安定な駆動が実現されるようになっている。

この態様によれば、実施の形態１と同様に、被駆動体が連結された従動プーリ

１５２，１５３に大きな負荷が作用したり、平ベルト１０５が蛇行しようとしても、平ベルト１０５の貫通孔１３０部への作用力を分散させながら被駆動体へ確実に駆動力を伝達することができる。

【００６４】

また、図９（ｂ）に係るベルト駆動装置１００は、３列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔１３１が重複しないように斜めに配列させ、かつ、プーリ１５１～１５４の全部あるいは一部には前記貫通孔１３１に対応した突起１４１を設けたものであり、図９（ａ）よりもベルト幅方向に対する剛性を強化することが可能である。

更に、図９（ｃ）に係るベルト駆動装置１００は、２列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔１３２を重複しないように斜めに配列させ、かつ、プーリ１５１～１５４の全部あるいは一部には前記貫通孔１３２に対応した突起１４２を設けたものである。

【００６５】

更にまた、図９（ｄ）に係るベルト駆動装置１００は、２列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔１３３を並べて配列させ、かつ、プーリ１５１～１５４の全部あるいは一部には前記貫通孔１３３に対応した突起１４３を設けたものである。

この図９（ｄ）の態様にあっては、ベルト蛇行が大きく発生する場合には好ましくないが、従動プーリ１５２，１５３へ負荷がかかったときに２列の貫通孔１３３が同時に噛み合い駆動するため、高負荷を駆動する時には有効な配列である。

よって、適用する駆動仕様に応じ、本実施の形態のような幾つかの構成を組み合わせることにより、安定な駆動を行い、かつ、高度な回転ムラ精度を達成することが可能となる。

【００６６】

◎実施の形態４

図１０は、本発明が適用された複写機（画像形成装置）８０の実施の形態４に適用されるベルト駆動装置の概要を示す。

同図において、複写機８０の基本的構成は、実施の形態１と略同様に、四つの感光体ドラム１１（１１Ｋ～１１Ｃ）と、二つの第一中間転写ドラム３１ａ，３１ｂと、第二中間転写ドラム３２とを備えたものであるが、ベルト駆動装置１６０の構成が実施の形態１と異なる。尚、実施の形態１と同様な構成要素については実施の形態１と同様な符号を付してここではその詳細な説明を省略する。

本実施の形態において、ベルト駆動装置１６０は、図１０～図１２に示すように、各感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、及び、第二中間転写ドラム３２を駆動するものであり、二つの平ベルト１７１，１７２と、これらの平ベルト１７１，１７２が張架せしめられる各種張架部材とを備えている。

ここで、張架部材としては、各感光体ドラム１１（１１Ｋ～１１Ｃ）、第一中間転写ドラム３１ａ，３１ｂ、及び、第二中間転写ドラム３２のそれぞれ軸方向一端に取り付けられた従動プーリ１８１～１８７と、各平ベルト１７１，１７２の取り回しを行うための張架プーリ１９１，１９２とがある。

尚、本実施の形態では、第二中間転写ドラム３２に取り付けられた従動プーリ１８７は第一、第二の平ベルト１７１，１７２がそれぞれ掛け渡される二段のベルト掛け渡し面を有している。

【００６７】

そして、第一の平ベルト１７１は、張架プーリ１９１と、各感光体ドラム１１（１１Ｋ～１１Ｃ）の軸に取り付けられた従動プーリ１８１～１８４と、第二中間転写体ドラム３２の軸に取り付けた従動プーリ１８７とに掛け渡されている。

一方、第二の平ベルト１０２は、張架プーリ１９２と、第一中間転写ドラム３１ａ，３１ｂの軸に取り付けた従動プーリ１８５，１８６と、第二中間転写体ドラム３２の軸に取り付けた従動プーリ１８７とに掛け渡されている。

尚、各プーリ１８１～１８７，１９１，１９２に設けられているプーリ軸（図示せず）は、複写機８０の側面に設けられる各すべり軸受により軸受され、各プーリは回転自在に構成されている。また、本例では、従動プーリ１８７の二段のベルト掛け渡し面のうち、第一の平ベルト１７１に対するベルト掛け渡し面が第二の平ベルト１７２に対するベルト掛け渡し面よりも大径に形成されている。

特に、本実施の形態では、平ベルト１７１，１７２は進行方向に沿って例えば一列の貫通孔１７５を具備し、これらが掛け渡されるプーリの全部若しくは一部には前記貫通孔１７５に対応した突起１７６を設け、両者を嵌合させることで、駆動力を伝達するパーフォレーションベルトにて構成されている。

【００６８】

ここで、図示外の駆動モータ（駆動源）からの出力をどの軸に与えるかであるが、平ベルトとプーリの巻き付け角度が大きいプーリ軸に駆動モータからの駆動を入力させる構成をとることが望ましい。

本実施の形態においては、例えば第二中間転写ドラム３２の軸へ駆動モータからの駆動力を入力するように設定することができるが、他のプーリ軸へ駆動モータからの駆動力を入力する構成としてもよい。

また、平ベルトの材質やプーリの材質については、実施の形態１と同様に適宜選定して差し支えなく、例えば平ベルトとしては、耐久性や加工精度等の面からステンレス、ニッケル、チタン等の金属を使用することが好ましい。一方、プーリの材質については、耐久性や加工精度等の面からステンレス、アルミニウム、炭素鋼等の金属を使用することが好ましい。

【００６９】

特に、本実施の形態においては、第一中間転写ドラム３１ａ，３１ｂの従動プーリ１８５，１８６には、同従動プーリ１８５，１８６軸と同軸で且つ自由回転可能な自由回転体２００（具体的には２００ａ，２００ｂ）が設けられており、平ベルト１７１は、感光体ドラム１１（１１Ｋ，１１Ｙ）の従動プーリ１８１，１８２には自由回転体２００ａを介して掛け渡され、一方、感光体ドラム１１（１１Ｍ，１１Ｃ）の従動プーリ１８３，１８４には自由回転体２００ｂを介して掛け渡されている。

ここで、自由回転体２００としては、軸に対して自由回転し得る部材であればカラーなどを始め適宜選定して差し支えないが、本例では、例えば図１３（ａ）（ｂ）に示すように、ボールベアリングが用いられる。このボールベアリングは、前記従動プーリ１８５，１８６軸に圧入連結される内輪ケース２０１と、この内輪ケース２０１の外側にボール２０３を介して回転自在に設けられる外輪ケー

ス２０２とで構成される。

【００７０】

また、自由回転体２００は、第一中間転写ドラム３１ａ，３１ｂの回転軸３１０の軸方向に対して位置を規制することが好ましい。

上記自由回転体２００が軸方向に自由度を持つと、平ベルト１７１，１７２の蛇行を発生させる原因となり、例えばパーフォレーションベルトのような孔付き平ベルトを使用している場合などでは、自由回転体２００の上流側、下流側の感光体ドラム１１（本例では１１Ｋ，１１Ｙ）用の従動プーリ１８１，１８２あるいは感光体ドラム１１（本例では１１Ｍ，１１Ｃ）用の従動プーリ１８３，１８４の突起１７６と平ベルト１７１，１７２の貫通孔１７５とが擦れ、貫通孔１７５部の破壊を招き易い。

ここで、自由回転体２００の軸方向規制としては、図１３（ｂ）に示すように、例えばＥリングやＯリング等の位置規制部材２１０を自由回転体２００の両側あるいは片側（本例では両側）に設けるようにすればよい。

【００７１】

また、本実施の形態において、上記自由回転体２００の周面には平ベルト１７１，１７２が掛け渡されているが、図１３（ｂ）に仮想線で示すように、自由回転体２００の周面（本例では外輪ケース２０２の周面）に平ベルト１７１，１７２の貫通孔１７５に対応して突起２０５を設け、自由回転体２００と平ベルト１７１，１７２との間の軸方向に対する位置規制を行うことがより好ましい。

【００７２】

次に、本実施の形態に係る画像形成装置のベルト駆動装置の作動について説明する。

本実施の形態において、第二中間転写ドラム３２の回転軸に駆動モータからの駆動力が入力されると、第二中間転写ドラム３２の従動プーリ１８７が回転し、第二の平ベルト１７２、従動プーリ１８５，１８６及び張架プーリ１９２を介して第一中間転写ドラム３１ａ，３１ｂに駆動力が伝達される。

一方、第二中間転写ドラム３２の従動プーリ１８７が回転すると、第一の平ベルト１７１、従動プーリ１８１～１８４、張架プーリ１９２及び自由回転体２０

０（２００ａ，２００ｂ）を介して各感光体ドラム１１（１１Ｋ～１１Ｃ）に駆動力が伝達される。

【００７３】

このとき、第一の平ベルト１７１は、各感光体ドラム１１の隣接し合う従動プーリ１８１～１８４に対し自由回転体２００ａ，張架プーリ１９１，自由回転体２００ｂを介して約１８０°以上の巻き付け角度をもって掛け渡されている。

この状況において、第一の平ベルト１７１と各従動プーリ１８１～１８４との巻き付け領域が増加することから、その分、従動プーリ１８１～１８４への駆動力の伝達が安定するばかりか、第一の平ベルト１７１の貫通孔１７５と従動プーリ１８１～１８４の突起１７６との嵌合による貫通孔１７５部に作用する力が分散するため、前記貫通孔１７５部に局部応力が作用することに伴う貫通孔１７５部の破壊は有効に回避される。

【００７４】

特に、本例では、第一中間転写ドラム３１ａ，３１ｂの回転軸方向と、自由回転体２００の回転方向とは逆方向であるが、自由回転体２００は第一中間転写ドラム３１ａ，３１ｂの回転軸に対して自由回転可能であるため、第一の平ベルト１７１の移動が損なわれることはない。

仮に、自由回転体２００がないとすれば、第一の平ベルト１７１を直接第一中間転写ドラム３１ａ，３１ｂの回転軸に巻き付けることになるが、このような態様にあっては、平ベルト１７１にかかる負荷及び駆動負荷が大きくなり、摩擦による第一の平ベルト１７１のダメージも大きくなってしまい、好ましいものではない。

【００７５】

更に、自由回転体２００は、第一中間転写ドラム３１ａ，３１ｂの回転軸を支持部材として使用するため、専用の張架プーリ支持部材は不要であり、また、自由回転体２００の設置スペースが不必要に拡大することはない。

【００７６】

また、本実施の形態に係るベルト駆動装置１６０は、上述したものに限定されるものではなく、例えば図１４に示すように設計変更しても差し支えない。

図１４に示すベルト駆動装置１６０は、減速機構を用いた形態を利用したものである。

同図において、減速機構は、駆動プーリ２２１が回転支持される軸２２０へ駆動モータ（図示せず）より駆動力が入力され、ベルト伝達により回転速度を減速させ、出力軸へ駆動力を伝達するものである。

ここで、従動プーリ２３１，２３２の回転軸は共通であり、この回転軸には、駆動モータからの入力を受ける駆動プーリ２２１と従動プーリ２３１とに第一の平ベルト２４１を掛け渡し、一方、従動プーリ２３２と出力軸２５０に設けられた従動プーリ２５１との間に第二の平ベルト２４２を掛け渡したものである。

【００７７】

このような減速機構において、出力軸２５０に大きな負荷がかかっている場合、第一の平ベルト２４１と第二の平ベルト２４２とでは、ベルトにかかる引っ張り負荷は異なり、第二の平ベルト２４２の方が大きな引っ張り負荷力を受けることになる。そのため、滑り等の点で第一の平ベルト２４１で十分であった巻き付け角度でも第二の平ベルト２４２では不十分となってしまう虞れがある。

このような状況下において、第二の平ベルト２４２が巻きかかる従動プーリ２５１への巻き付け角度を大きくする場合には、図１４に示すように、駆動プーリ２２１の回転軸（入力軸）２２０にこの軸２２０と同軸で且つ自由回転自在な自由回転体２００を設け、この自由回転体２００に対し、第二の平ベルト２４２を巻き付けることで、余計な張架プーリ支持部材を設けることなく、かつ、スペースを必要とすることなく、従動プーリ２３２、従動プーリ２５１に対する第二の平ベルト２４２が巻き付く角度を増加させることが可能となる。

【００７８】

尚、実施の形態２に係る画像形成装置のベルト駆動装置に本実施の形態に示すベルト駆動装置１６０（自由回転体２００を使用した態様）を適用してもよいことは勿論である。

【００７９】

【実施例】

◎実施例１

実施の形態１に係る画像形成装置を実施例モデルとし、出力画像の濃度ムラや画像位置ずれについて実際に調べたところ、本発明者らの実験によれば、孔無し平ベルトでは滑りが生じ駆動不可能な従動プーリ軸トルクが作用する条件下であっても、出力画像の濃度ムラや画像位置ずれは認知限界以下にまで低減させることに成功した。

その一例を図１５に示す。

同図では、ベルトの貫通孔部とプーリ突起との噛み合い変動を目標レベルとする$\Delta V_{0\text{-}p}$＜０．３％とすることができ、画像濃度ムラの認知限界以下にすることができた。

【００８０】

また、本実施例によれば、ベルト初期張力を大きくすることで発生するベルト蛇行による影響も低減できた。

その一例を図１６に示す。尚、図１７に比較例（ベルト貫通孔が１列孔）の場合の結果を示す。

先ず、比較例について検討して見るに、図１７には、①従動プーリに負荷を与えずにベルト張力をT_0→T_1へ上げていき（Ｃ１領域参照）、次に、②ベルト張力をT_0へ戻し、負荷を目標とする値の半分だけ従動プーリに与え、先程と同様にベルト張力をT_0→T_1へ上げていき（Ｃ２領域参照）、更には、③ベルト張力をT_0へ戻し、負荷を目標とする値で与え、ベルト張力をT_0→T_1へ上げていった（Ｃ３領域参照）連続駆動時の回転ムラレベル経過が示されている。

【００８１】

同図から分かるように、①から②へ変更する場合には、ベルト張力を初期状態に戻しているにも関わらず回転ムラのレベルは、初期状態に戻っていないことが分かる。これは、①が無負荷駆動であるため負荷による影響ではなく、ベルト張力をT_1まで上げていくときに、ベルト蛇行が発生し、貫通孔部にダメージを与えたものである。

また、負荷を加えた②，③では、回転ムラレベルが次第に悪化しており、負荷とこのベルト蛇行の影響が入り交じっていることが分かる。

実験終了後にベルト貫通孔部を観察した所、突起との噛み合いで生じたダメー

ジが塑性変形しており、ある所では亀裂が生じていた。このような現象が生じてしまうと画像形成装置としてはもちろん、駆動力伝達装置としての役割を果たすことが困難となってしまう。

【００８２】

これに対し、本実施例を導入した結果を見ると、図１６には、①ベルト張力をT_0とし、従動プーリに負荷を０から徐々に目標値に挙げていき（Ａ１領域参照）、次に、②ベルト張力をT_0へ戻した後、ベルト張力をT_1（T_0×１．４）とし、従動プーリに負荷を０から徐々に目標値に挙げていき（Ａ２領域参照）、更には、③ベルト張力をT_0へ戻した後、ベルト張力をT_2（T_0×１．７）とし、従動プーリに負荷を０から徐々に目標値に挙げていった（Ａ３領域参照）連続駆動時の回転ムラレベル経過が示されている。

同図によれば、従動プーリの負荷を上げていくと回転ムラが多少悪化する傾向が見られるが、そのレベルは小さく、また、ベルト張力を上げることにより発生する蛇行の影響もほとんどない。すなわち、実験途中に、ベルト張力を初期状態に戻し、無負荷とした時は、回転ムラのレベルも初期状態にもどっており、再現性がある。

逆に、ベルト張力を上げることによりプーリとベルトとのグリップ力が上がり、噛み合いによって生じる回転ムラが低減している。

よって、本実施例の導入により、出力画像の濃度ムラ認知限界である$\Delta V0\text{-}p$を０．３％以下とすることができ、かつ、負荷やベルト蛇行に対しても信頼性の高い駆動力伝達方式を提供することができた。

【００８３】

◎実施例２

実施の形態４に係る画像形成装置を実施例モデルとし、出力画像の濃度ムラや画像位置ずれについて実際に調べたところ、本発明者らの実験によれば、孔無し平ベルトを使用した態様であっても、プーリに対する平ベルトの巻き付け角度を充分に大きくすることができるため、平ベルトとプーリとの間の滑りは有効に回避することが可能である。

また、孔無し平ベルトでは滑りが生じ駆動不可能な従動プーリ軸トルクが作用

する条件下であっても、出力画像の濃度ムラや画像位置ずれは認知限界以下にまで低減させることに成功した。

その一例を図１８に示す。

同図によれば、ベルトの貫通孔部とプーリ突起との噛み合い変動を目標レベルとする$\Delta V_{0\text{-}p}$＜０．３％とすることができ、画像濃度ムラの認知限界以下にすることができた。

【００８４】

【発明の効果】

以上詳細に説明したように、本発明に係る駆動力伝達装置によれば、複数の張架部材に無端状の平ベルトを掛け渡すことで駆動力を伝達する方式において、平ベルトの進行方向に沿って複数列の貫通孔を設け、平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を設けるようにしたので、平ベルトと張架部材との間の滑りを有効に防止できることは勿論、張架部材のいずれかに連結される被駆動体に大きな回転負荷がかかる状態であっても、貫通孔部に作用する力を効果的に分散でき、貫通孔部の破壊を有効に防止しながら、被駆動体に対し安定的に駆動力を伝達することができる。

このため、このような駆動力伝達装置を用いた画像形成装置にあっては、孔付き平ベルトの貫通孔部の破壊を有効に抑え、被駆動体である像担持体に対し安定的に駆動力を伝達することができるので、孔付き平ベルトの寿命を延ばしながら、画像欠陥のない出力画像を得ることができる。

【００８５】

また、本発明に係る駆動力伝達装置によれば、複数の張架部材に無端状の平ベルトを掛け渡すことで駆動力を伝達する方式において、駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して自由回転可能な自由回転体を同軸に設け、この自由回転体が設けられた張架部材とは異なって隣接し合う張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたしたので、例えば隣接し合う張架部材に対する平ベルトの巻き付け角度を大きく設定することが可能になり、しかも、自由回転体の設置スペースとして独自のスペースを必要としないで済む。

このため、例えば隣接し合う張架部材の少なくとも一方に被駆動体を連結する態様において、被駆動体に大きな回転負荷がかかる状態であっても、平ベルト引き回しのための補助張架部材支持部材の設置スペースを独自に必要とせず、レイアウトスペースを不必要に広げることなく、被駆動体に対し安定的に駆動力を伝達することができる。

更に、このような駆動力伝達装置を用いた画像形成装置にあっては、平ベルト引き回しのための独自の補助張架部材支持部材等を不要とし、しかも、被駆動体である像担持体に対し安定的に駆動力を伝達することができるので、装置の大型化を回避しながら、画像欠陥のない出力画像を得ることができる。

【図面の簡単な説明】

【図１】　（ａ）は本発明に係る駆動力伝達装置の概要を示す説明図、（ｂ）は本発明の別の態様に係る駆動力伝達装置の概要を示す説明図である。

【図２】　実施の形態１に係る画像形成装置の全体構成を示す説明図である。

【図３】　実施の形態１で用いられる駆動力伝達装置の詳細を示す斜視説明図である。

【図４】　実施の形態１で用いられる駆動力伝達装置の正面説明図、（ｂ）はその平面説明図である。

【図５】　（ａ）は実施の形態１で用いられる駆動力伝達装置の要部を示す説明図、（ｂ）は（ａ）中Ｂ方向から見た矢視図、（ｃ）は（ａ）中Ｃ方向から見た矢視図である。

【図６】　（ａ）は比較の形態における平ベルトの貫通孔とプーリの突起との噛み合い状態を示す説明図、（ｂ）は本実施の形態における平ベルトの貫通孔とプーリの突起との噛み合い状態を示す説明図、（ｃ）は本実施の形態の変形形態における平ベルトの貫通孔とプーリの突起とのベルト蛇行時の噛み合い状態を示す説明図、（ｄ）は本実施の形態における平ベルトの貫通孔とプーリの突起とのベルト蛇行時の噛み合い状態を示す説明図である。

【図７】　実施の形態１で用いられる駆動力伝達装置の変形形態を示す説明図である。

【図８】　実施の形態２に係る画像形成装置の全体構成を示す説明図である。

【図９】　（ａ）～（ｄ）は実施の形態３に係る駆動力伝達装置及びその変形形態を示す説明図である。

【図１０】　実施の形態４に係る画像形成装置の要部を示す説明図である。

【図１１】　実施の形態４で用いられる駆動力伝達装置の概要を示す斜視説明図である。

【図１２】　実施の形態４で用いられる駆動力伝達装置を図１１の背面側から見た斜視説明図である。

【図１３】　（ａ）は自由回転体の具体例を示す説明図、（ｂ）は自由回転体の軸方向に対する位置規制例を示す説明図である。

【図１４】　実施の形態４で用いられる駆動力伝達装置の変形形態を示す説明図である。

【図１５】　実施例１に係る駆動力伝達装置における従動プーリの回転ムラを示す説明図である。

【図１６】　実施例１に係る駆動力伝達装置の駆動結果を示す説明図である。

【図１７】　比較例に係る駆動力伝達装置の駆動結果を示す説明図である。

【図１８】　実施例２に係る駆動力伝達装置における従動プーリの回転ムラを示す説明図である。

【図１９】　従来の駆動力伝達装置の不具合を示す説明図である。

【図２０】　従来の駆動力伝達装置を用いた画像形成装置において濃度ムラ許容値と像担持体の回転ムラとの関係を示す説明図である。

【図２１】　従来の平ベルトを用いた駆動力伝達装置における従動プーリの平均回転速度と負荷トルクとの関係を示す説明図である。

【図２２】　従来の平ベルトを用いた駆動力伝達装置の一例を示す説明図である。

【図２３】　（ａ）は従来の平ベルトを用いた駆動力伝達装置の他の例を示す説明図、（ｂ）は（ａ）中Ｂ方向から見た矢視図である。

【図２４】　図２３に係る駆動力伝達装置における従動軸負荷と従動プーリ回転平均速度との関係を示す説明図である。

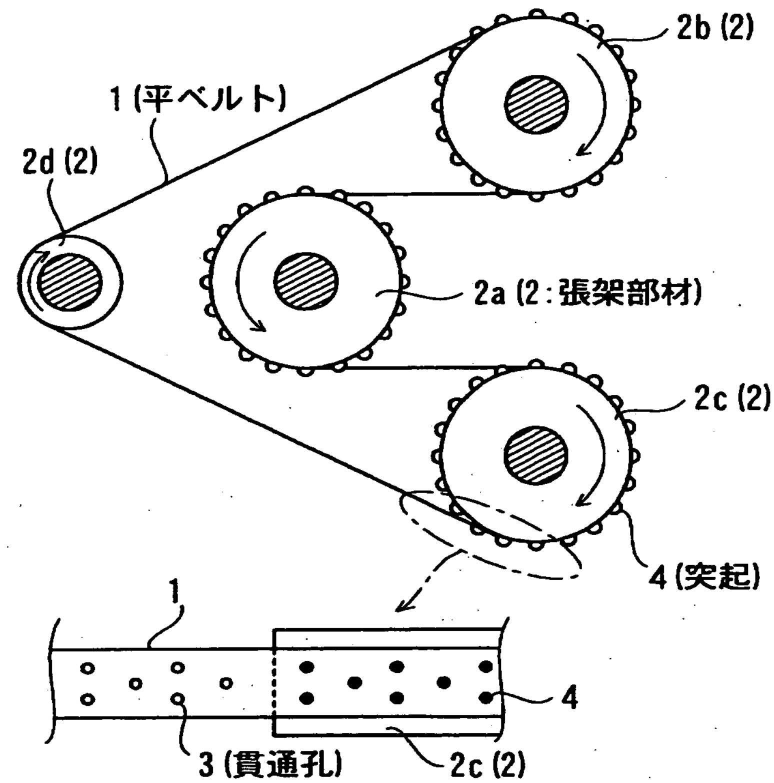
【符号の説明】

１…平ベルト，２（２ａ～２ｄ）…張架部材，３…貫通孔，４…突起，５…自由回転体

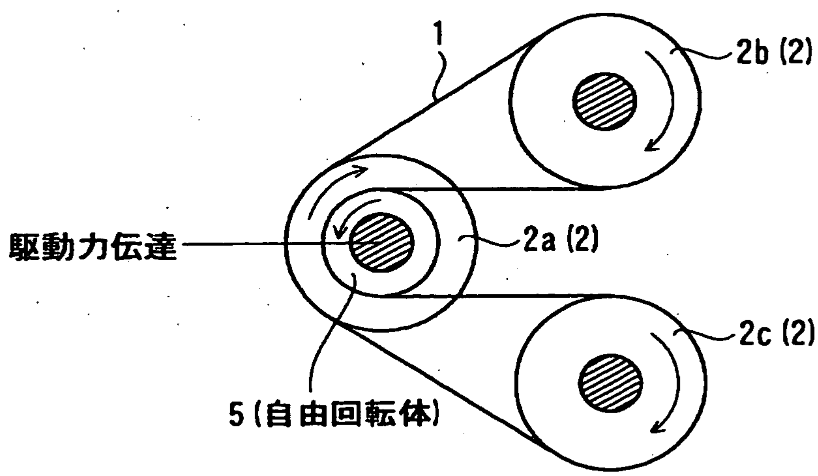
【書類名】　　　　図面

【図１】

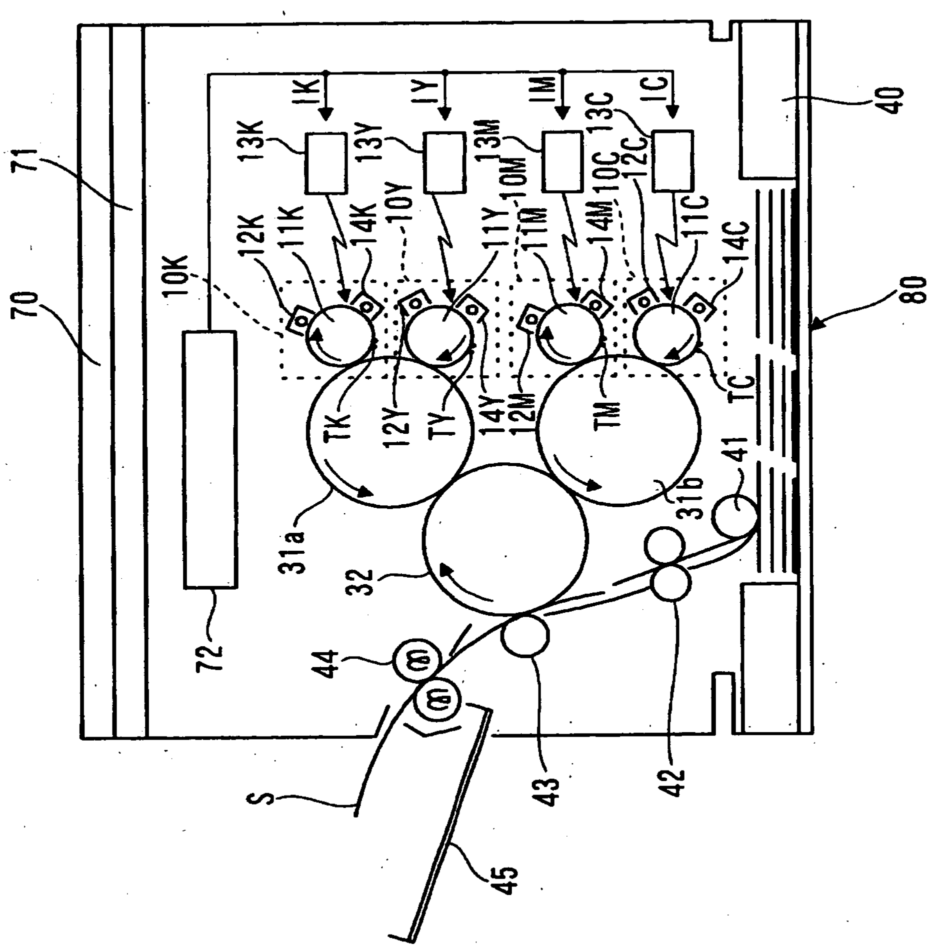
（ａ）


2b (2)
1 (平ベルト)
2d (2)
2a (2：張架部材)
2c (2)
4 (突起)
1
4
3 (貫通孔)
2c (2)

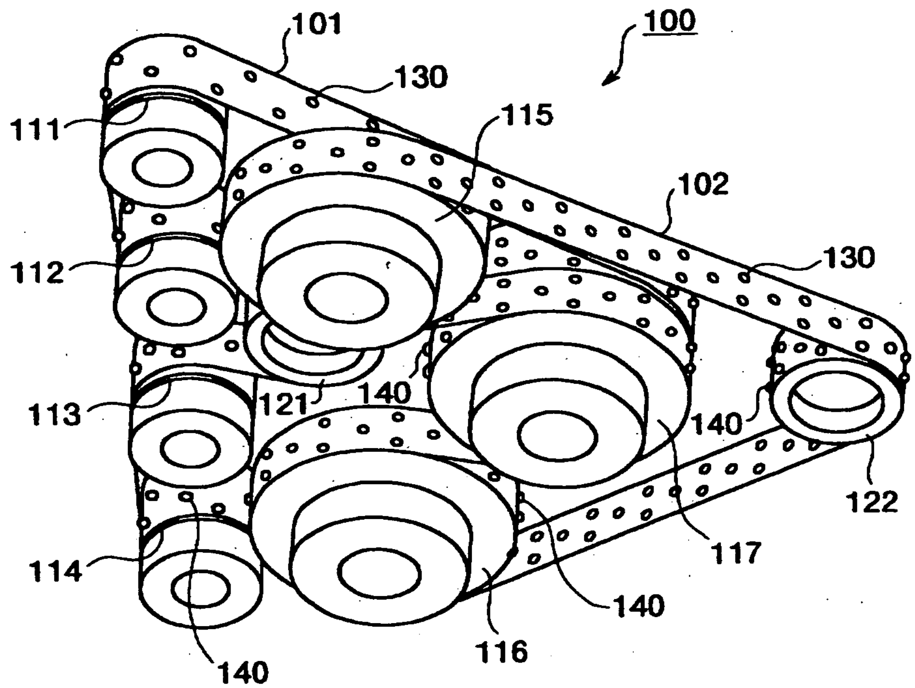
（ｂ）


1
2b (2)
駆動力伝達
2a (2)
2c (2)
5 (自由回転体)

【図２】

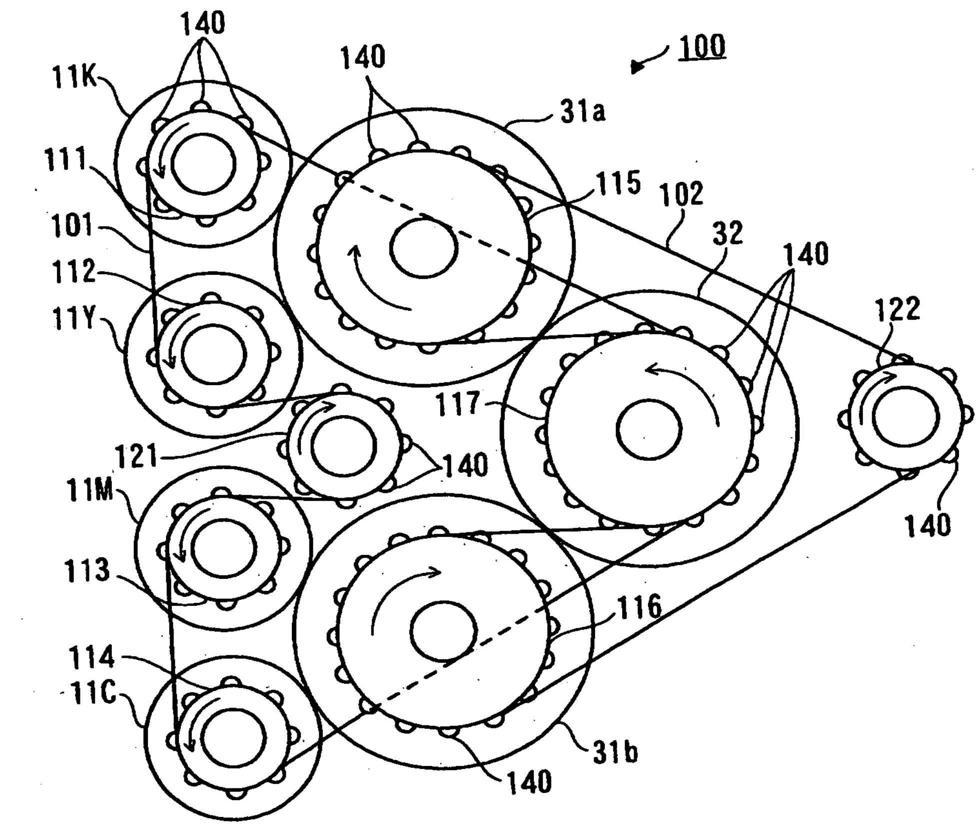

70
71
72
40
80
IK
IY
IM
IC
13K
13Y
13M
13C
10K
10Y
10M
10C
11K
11Y
11M
11C
12K
12Y
12M
12C
14K
14Y
14M
14C
TK
TY
TM
TC
31a
31b
32
41
42
43
44
45
S

【図３】

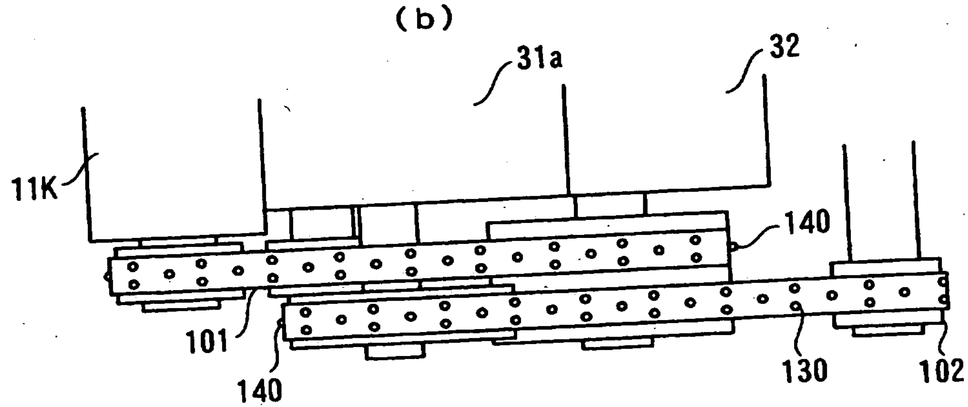

100
101
130
111
115
102
112
130
121
140
113
140
122
117
114
140
116
140

【図４】

（ａ）

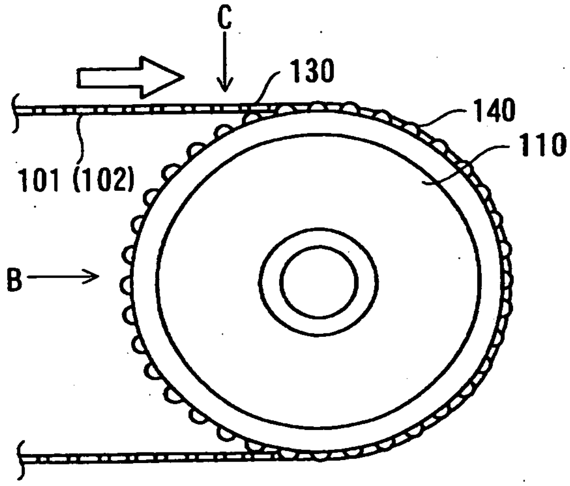

140
140
100
11K
31a
111
115
102
101
32
112
140
11Y
122
117
121
140
11M
140
113
116
114
11C
31b
140

（ｂ）

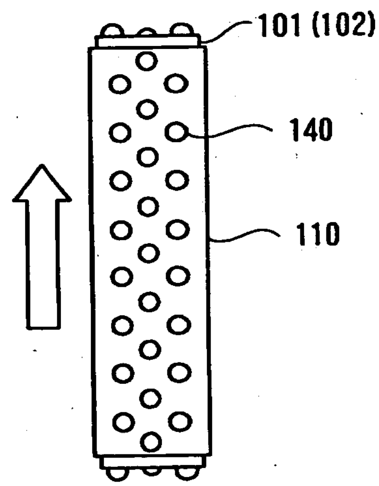

31a
32
11K
140
101
140
130
102

【図５】

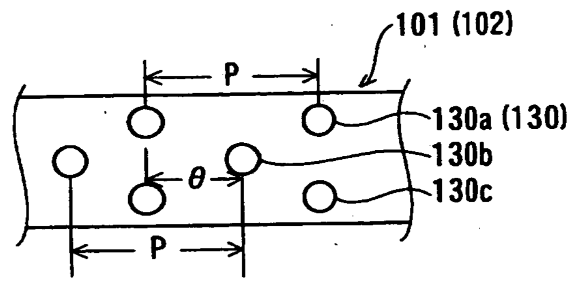
（ａ）


C
130
140
110
101 (102)
B

（ｂ）

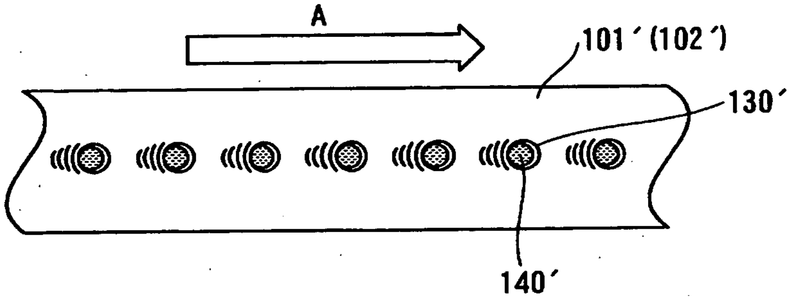

101 (102)
140
110

（ｃ）

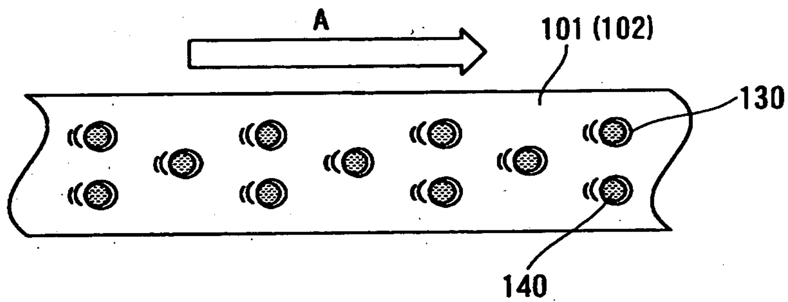

101 (102)
P
130a (130)
130b
θ
130c
P

【図６】

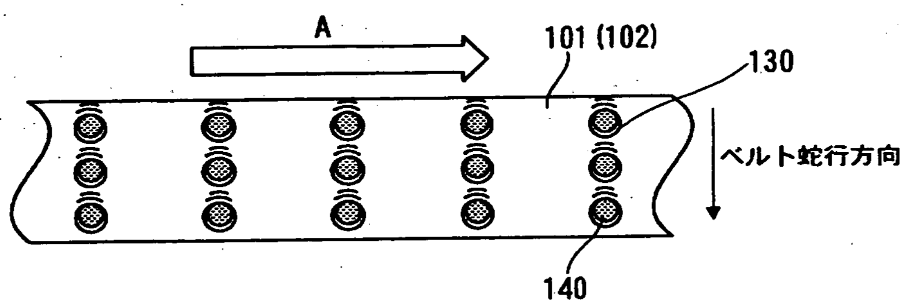
(a)


A
101′(102′)
130′
140′

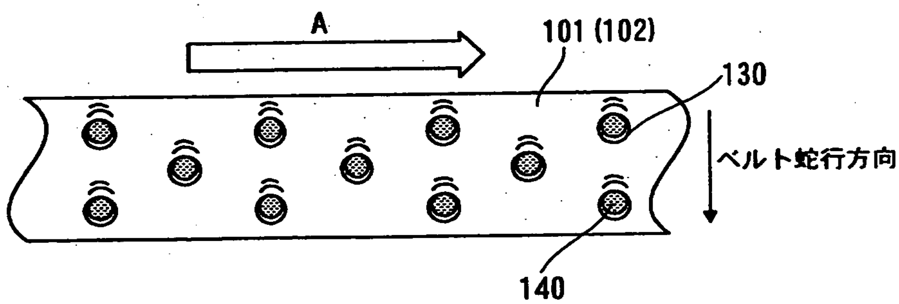
(b)


A
101 (102)
130
140

(c)

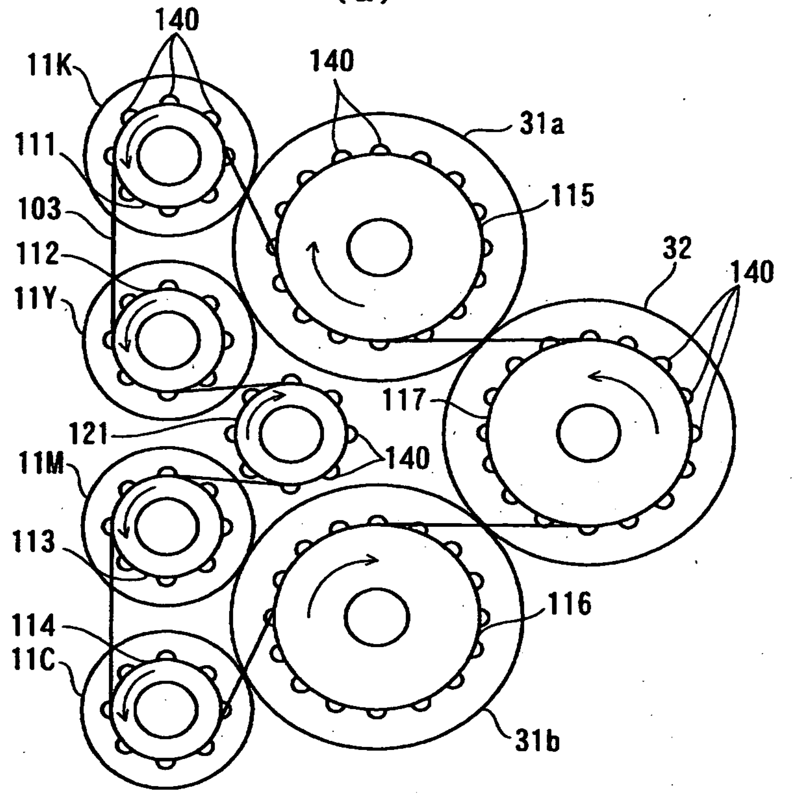

A
101 (102)
130
ベルト蛇行方向
140

(d)

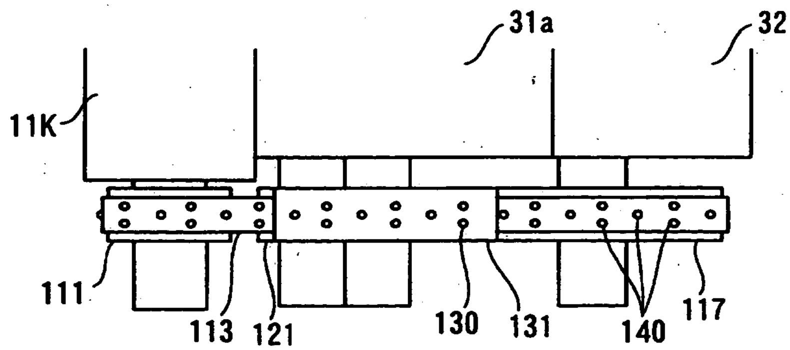

A
101 (102)
130
ベルト蛇行方向
140

【図７】

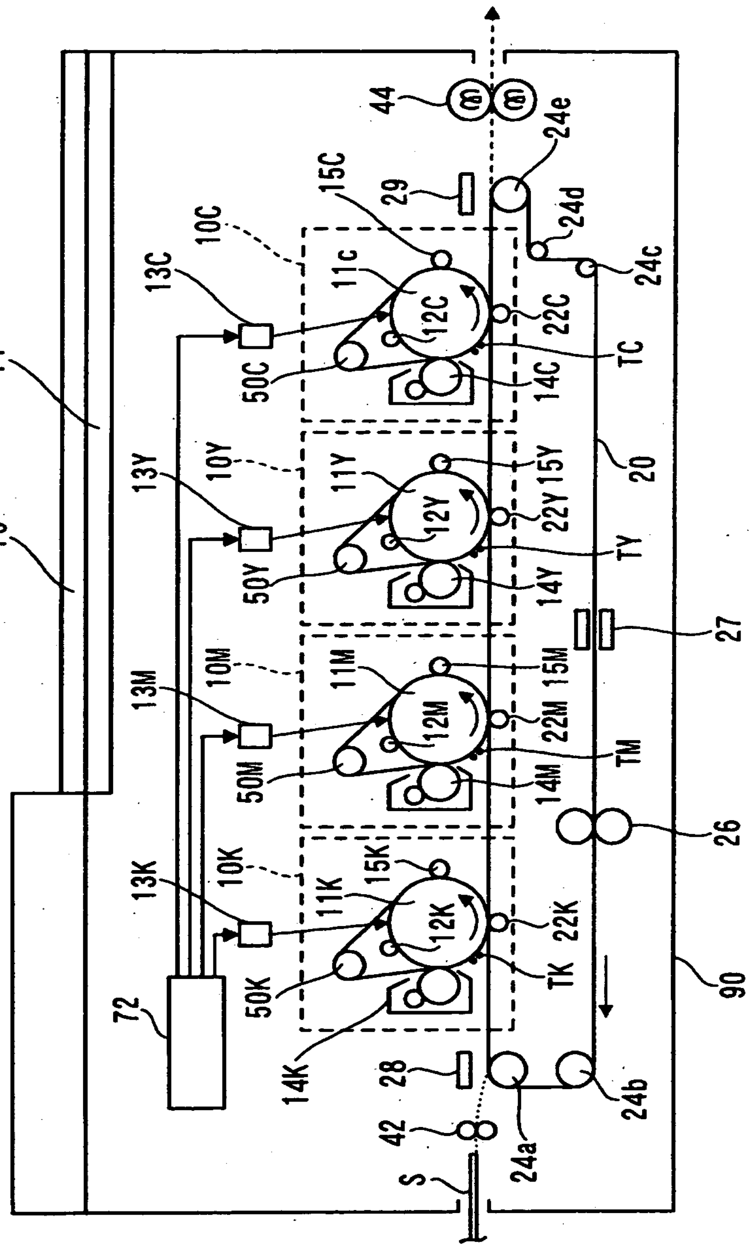
(a)


140
11K
140
31a
111
115
103
32
140
112
11Y
117
121
140
11M
113
116
114
11C
31b

(b)

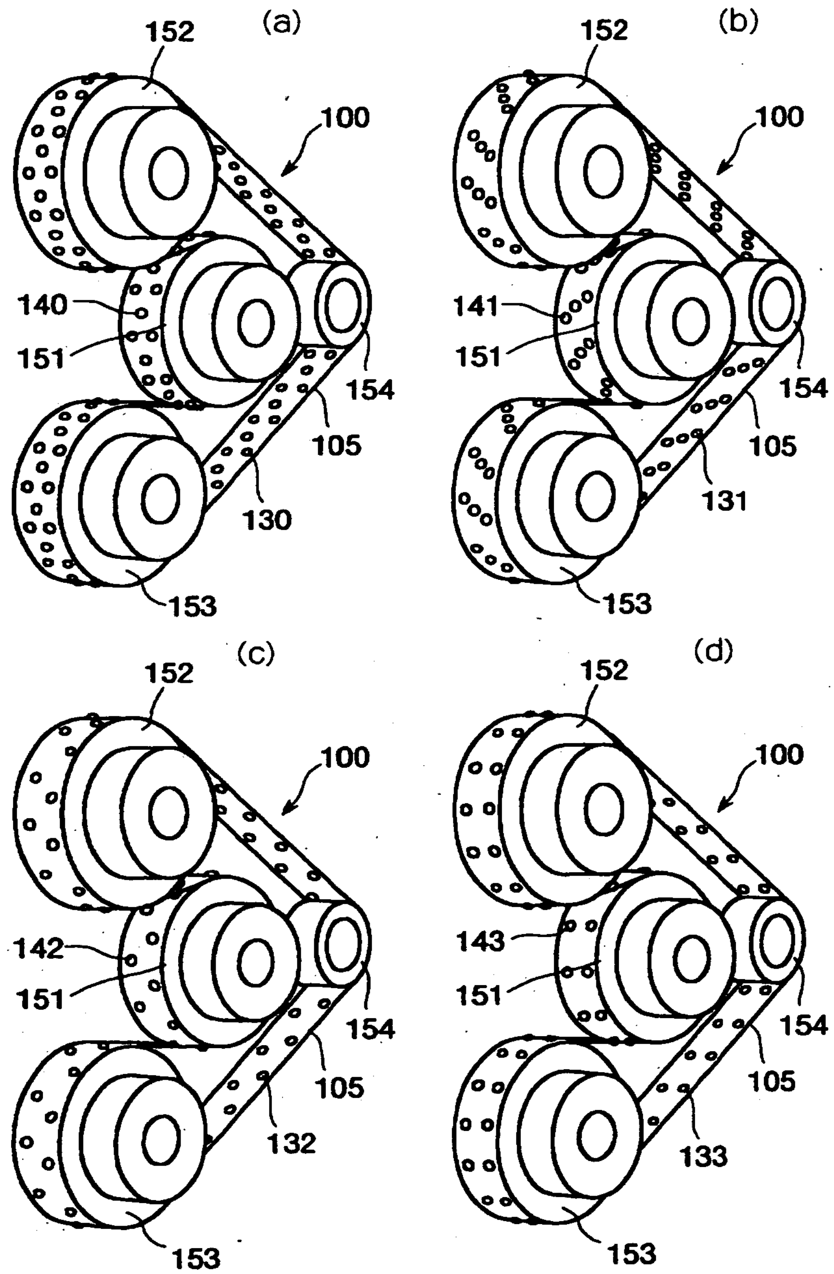

31a
32
11K
111
113
121
130
131
140
117

【図８】

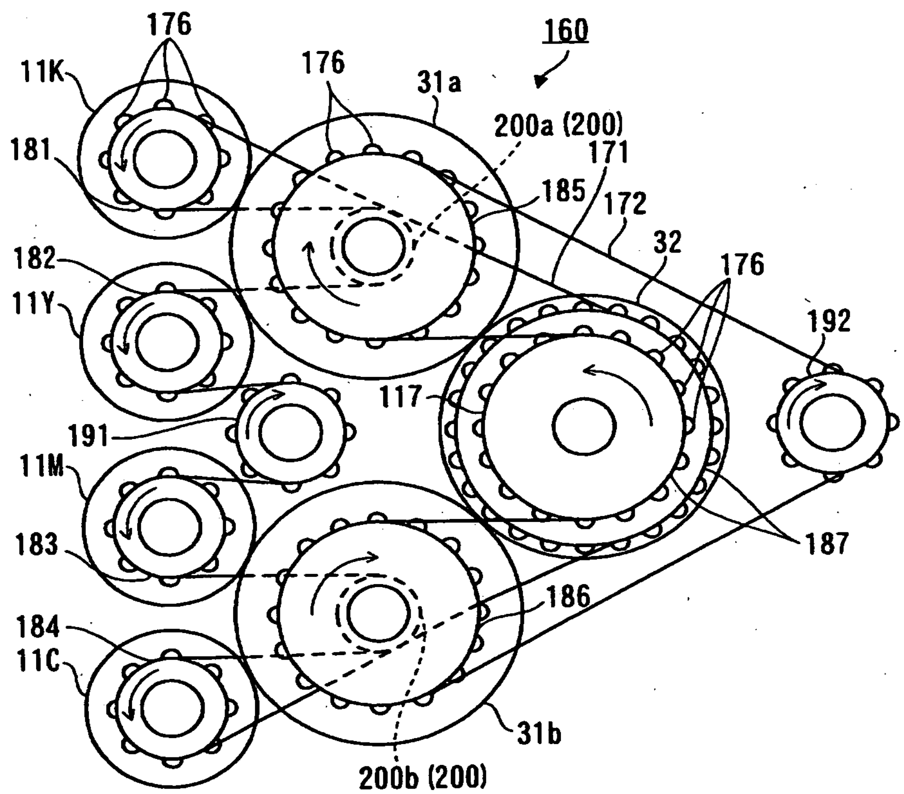


44
24e
29
15C
10C
24d
24c
13C
11c
12C
22C
TC
50C
14C
71
13Y
10Y
11Y
15Y
12Y
22Y
TY
20
50Y
14Y
70
27
13M
10M
11M
15M
12M
22M
TM
50M
14M
26
13K
10K
15K
11K
12K
22K
50K
TK
90
72
14K
28
24b
42
24a
S

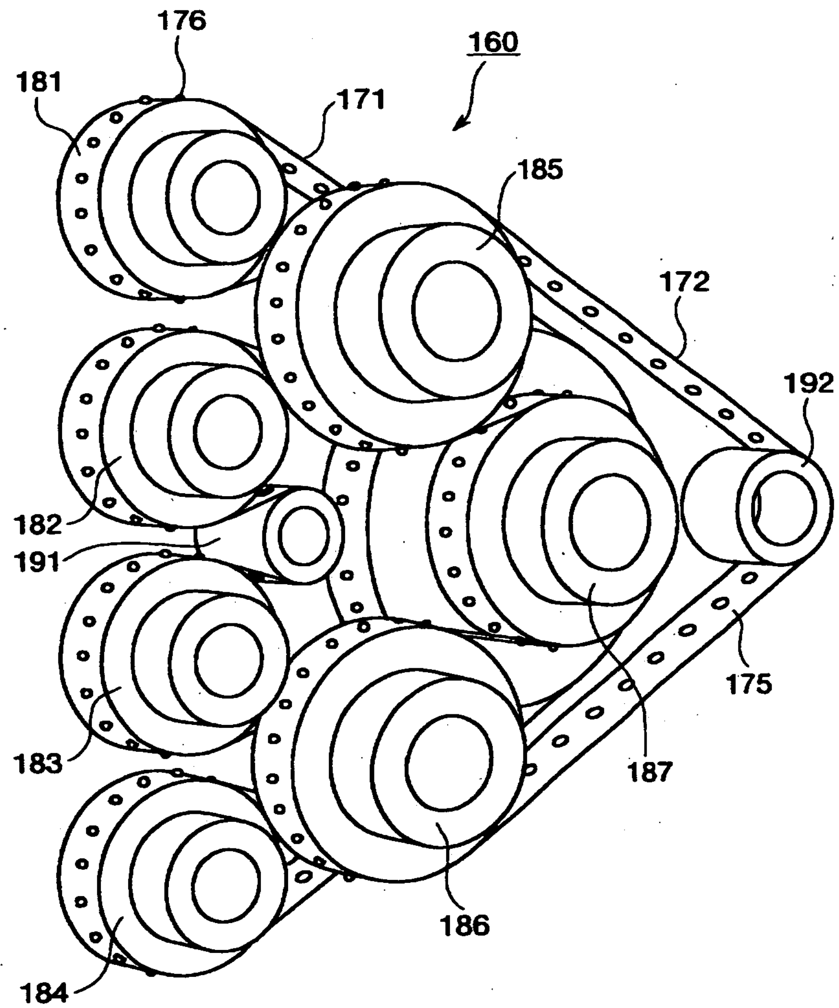
【図９】


(a)
152
100
140
151
154
105
130
153
(b)
152
100
141
151
154
105
131
153
(c)
152
100
142
151
154
105
132
153
(d)
152
100
143
151
154
105
133
153

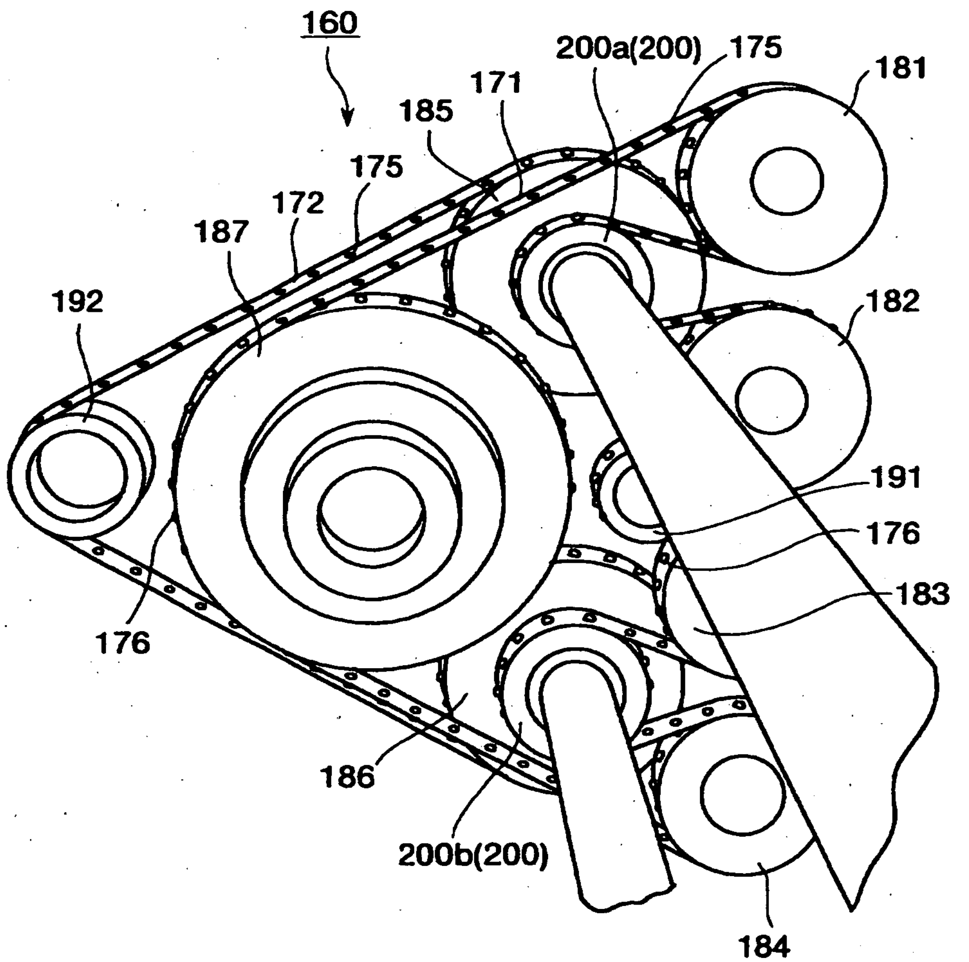
【図１０】


160
176
176
11K
31a
200a (200)
171
181
185
172
32
182
176
11Y
192
117
191
11M
187
183
186
184
11C
31b
200b (200)

【図１１】

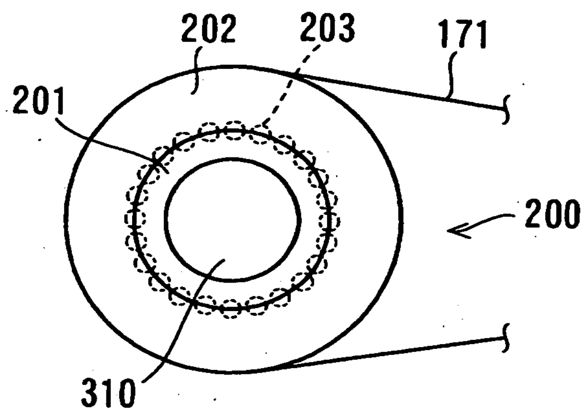


【図１２】

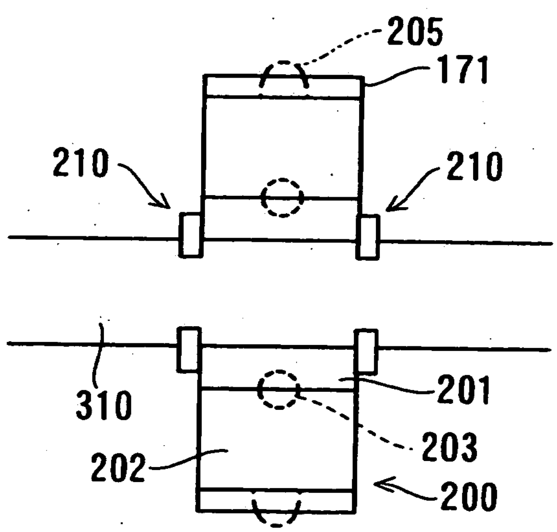

160
200a(200)
175
181
171
185
175
172
187
192
182
191
176
183
176
186
200b(200)
184

【図１３】

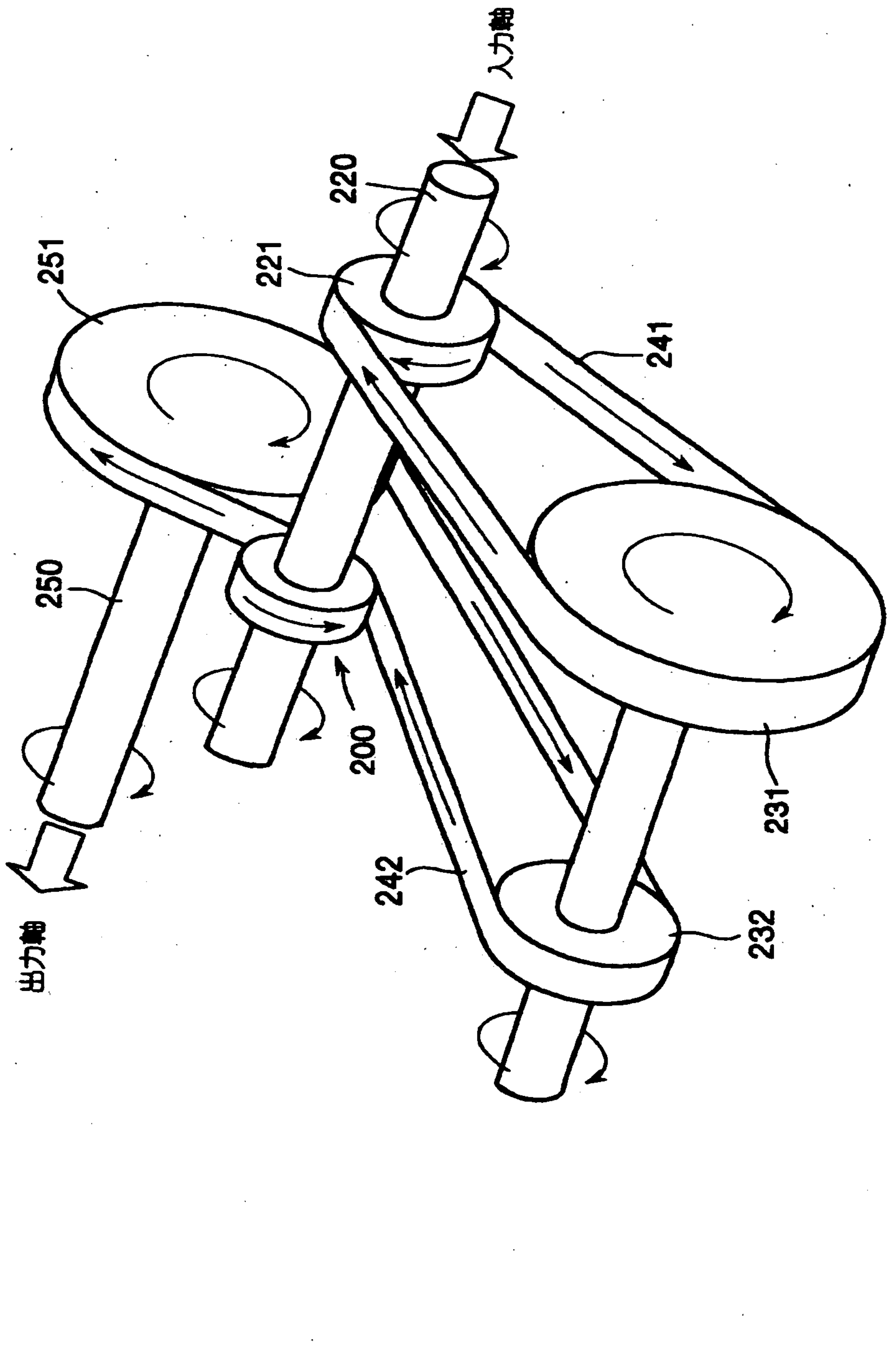
（ａ）



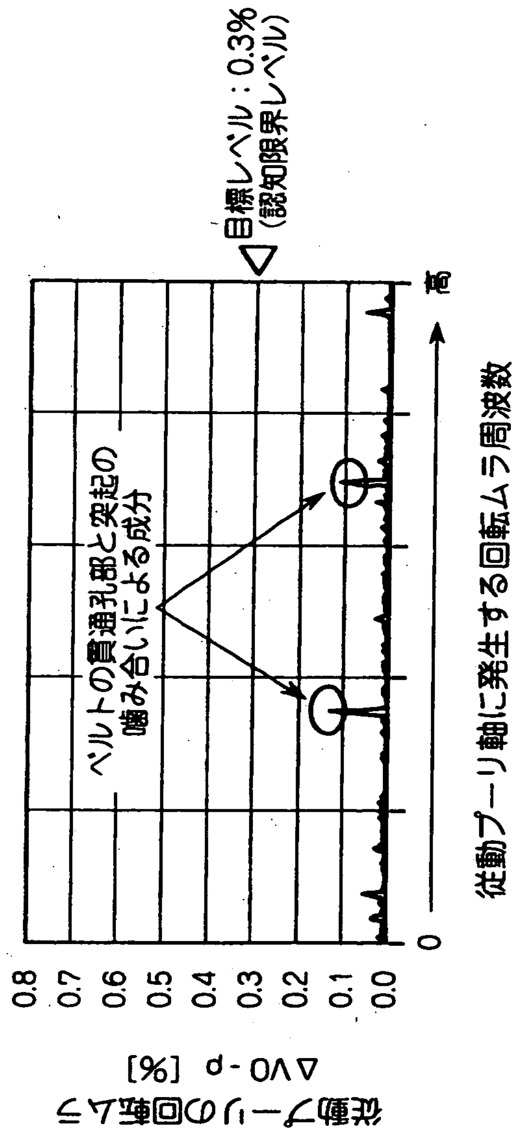
（ｂ）



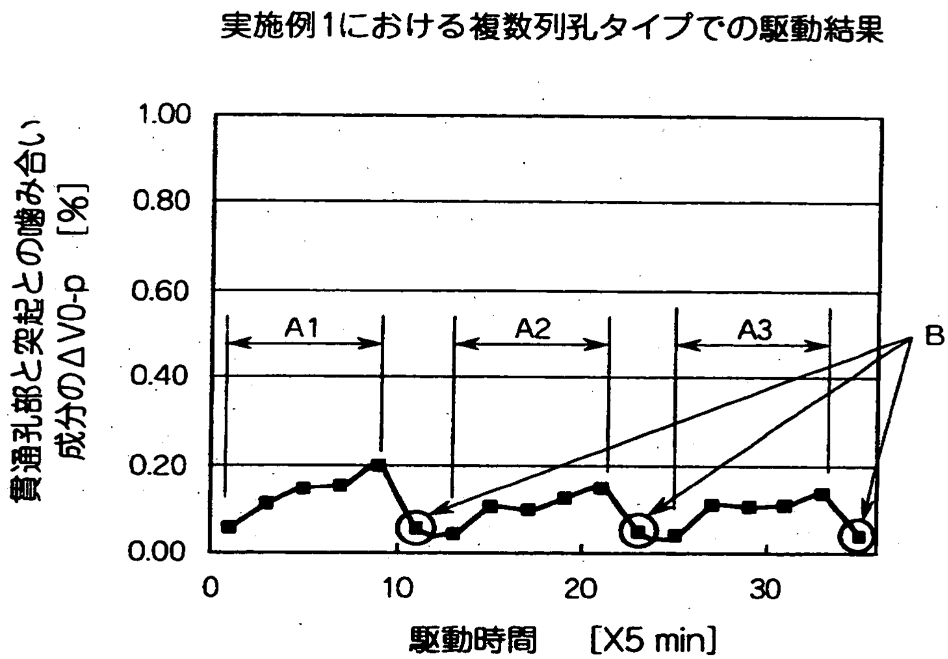
【図１４】



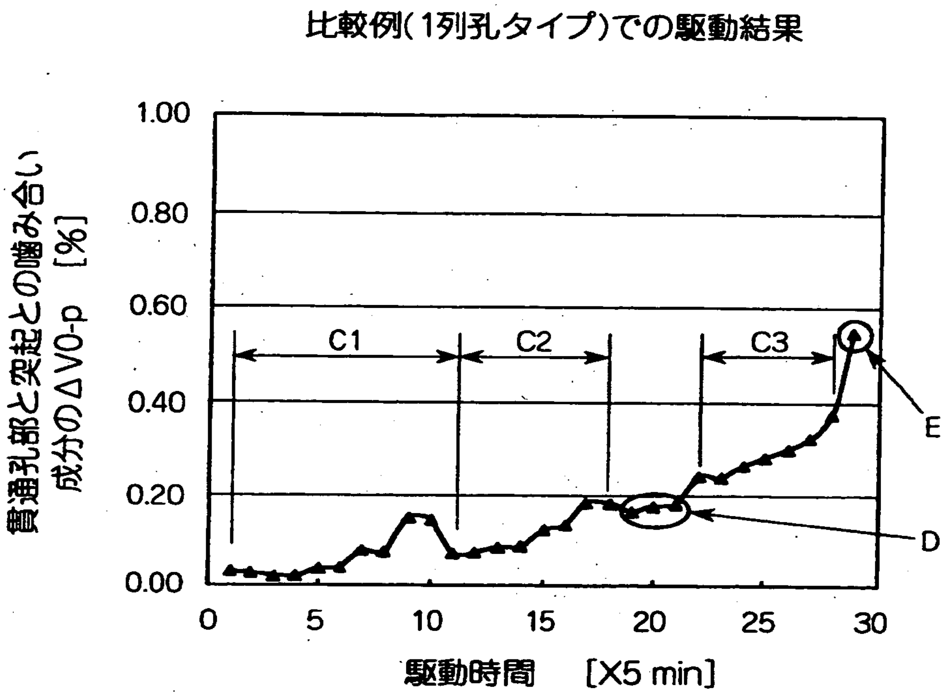
【図１５】


目標レベル：0.3%
（認知限界レベル）
ベルトの貫通孔部と突起の
噛み合いによる成分
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
従動プーリの回転ムラ
ΔV0-p [%]
0
高
従動プーリ軸に発生する回転ムラ周波数

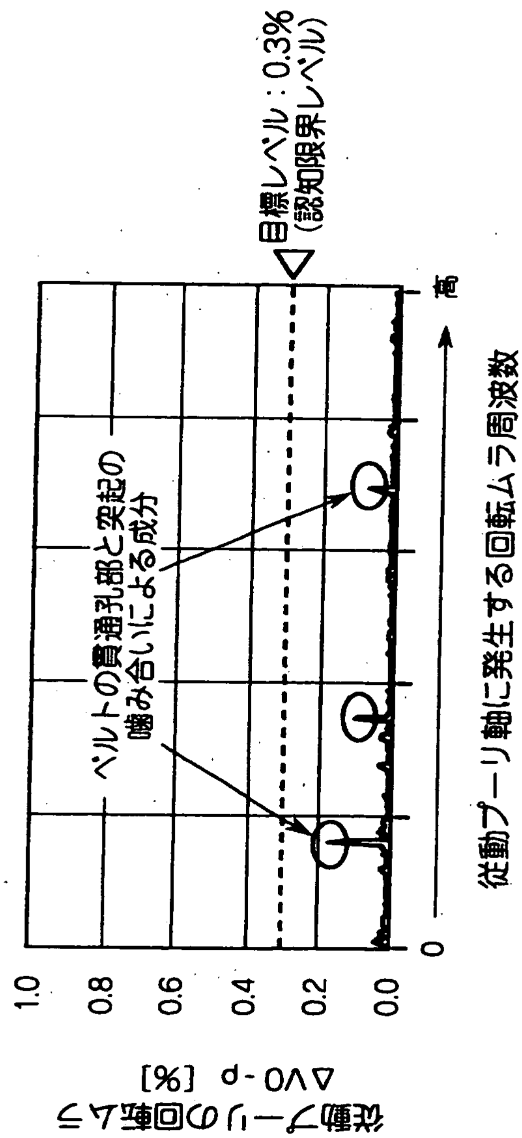
【図１６】


実施例1における複数列孔タイプでの駆動結果
貫通孔部と突起との噛み合い成分のΔV0-p [%]
1.00
0.80
0.60
0.40
0.20
0.00
0
10
20
30
A1
A2
A3
B
駆動時間 [X5 min]

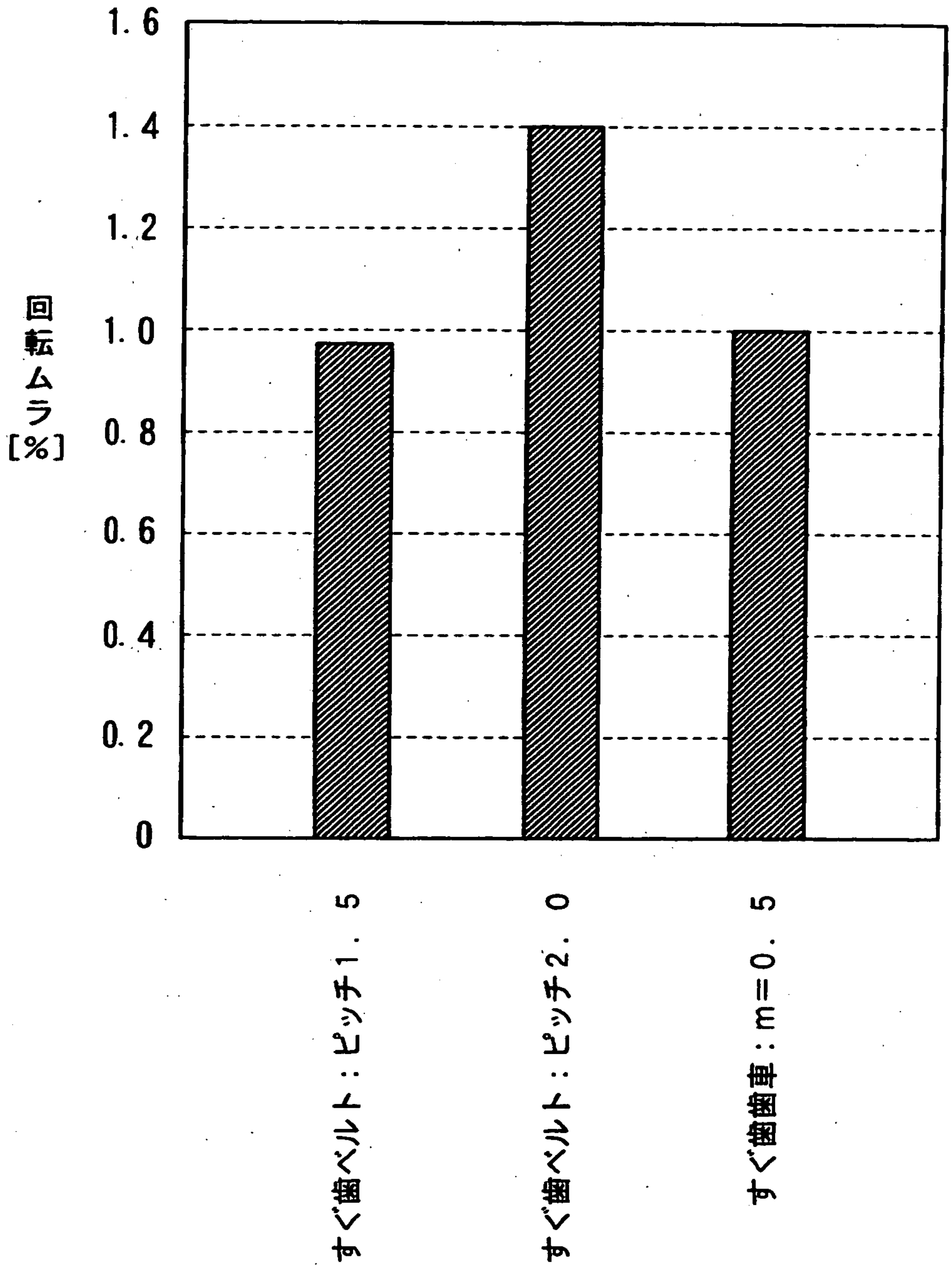
【図１７】


比較例(1列孔タイプ)での駆動結果
貫通孔部と突起との噛み合い成分のΔV0-p [%]
1.00
0.80
0.60
0.40
0.20
0.00
C1
C2
C3
E
D
0
5
10
15
20
25
30
駆動時間 [X5 min]

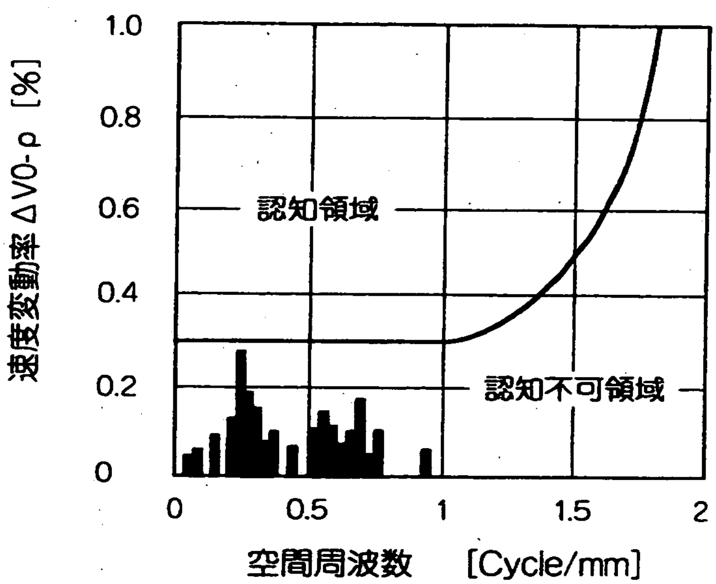
【図１８】


目標レベル：0.3%
(認知限界レベル)
ベルトの貫通孔部と突起の噛み合いによる成分
従動プーリの回転ムラ
ΔV0-p [%]
1.0
0.8
0.6
0.4
0.2
0.0
0
高
従動プーリ軸に発生する回転ムラ周波数

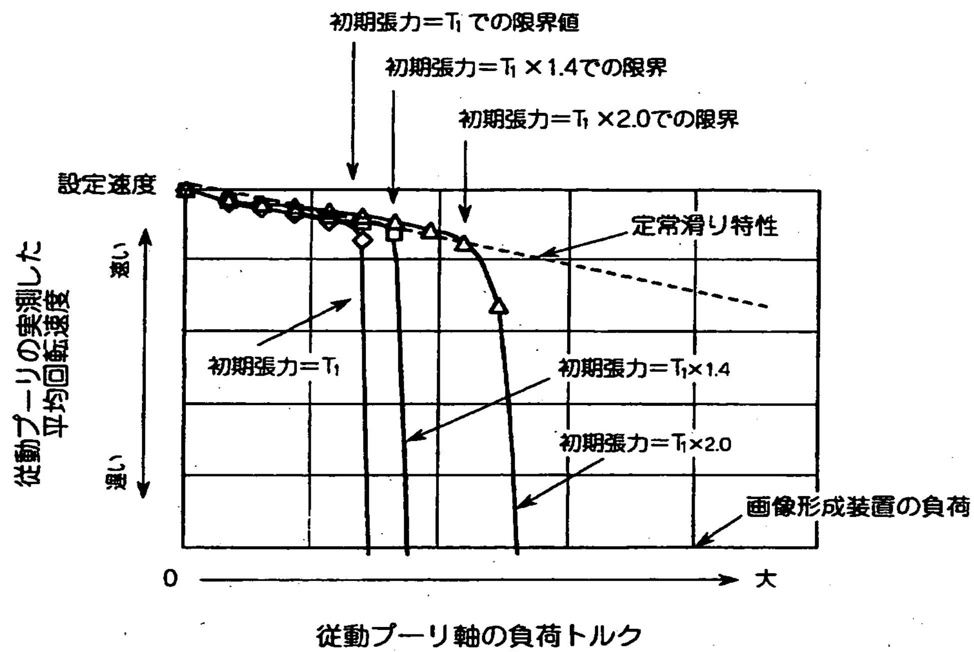
【図１９】


1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
回転ムラ[%]
すぐ歯ベルト：ピッチ１．５
すぐ歯ベルト：ピッチ２．０
すぐ歯歯車：m＝０．５

【図２０】



【図２１】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初期張力＝T1 ×1.4での限界
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設定速度
定常滑り特性
速い
遅い
従動プーリの実測した平均回転速度
初期張力＝T1
初期張力＝T1×1.4
初期張力＝T1×2.0
画像形成装置の負荷
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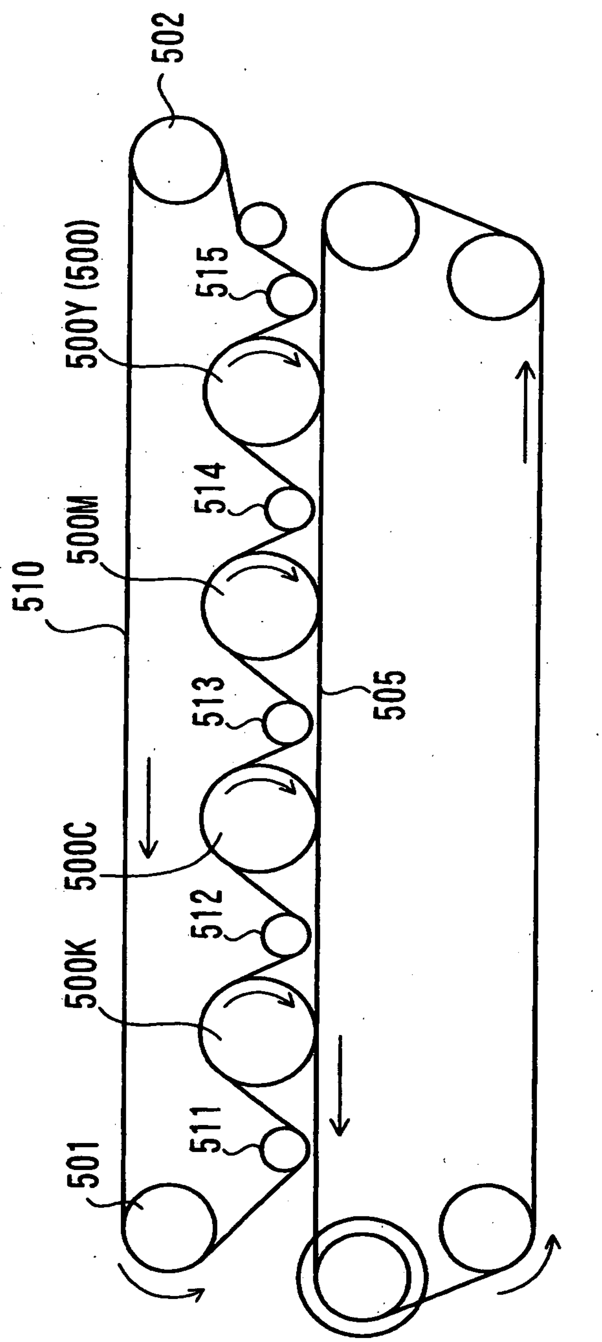
大
従動プーリ軸の負荷トルク

【図２２】



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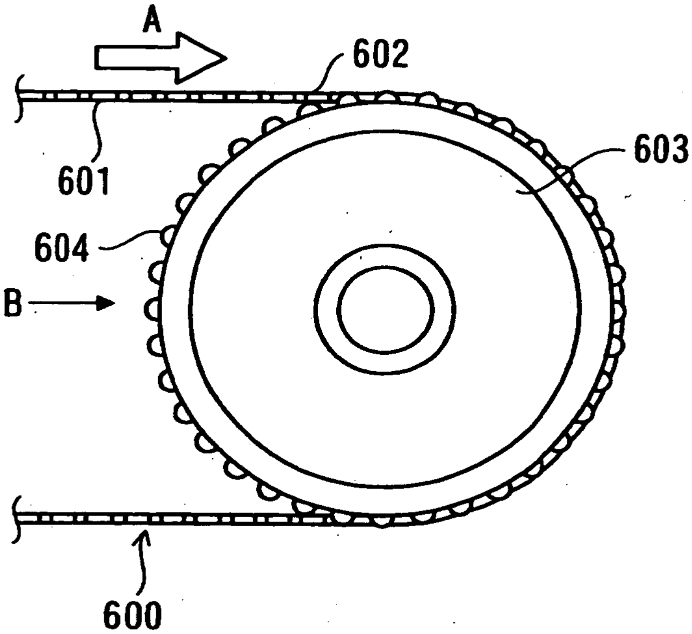
（ａ）



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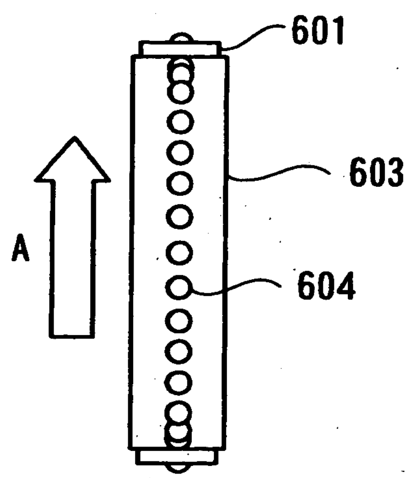

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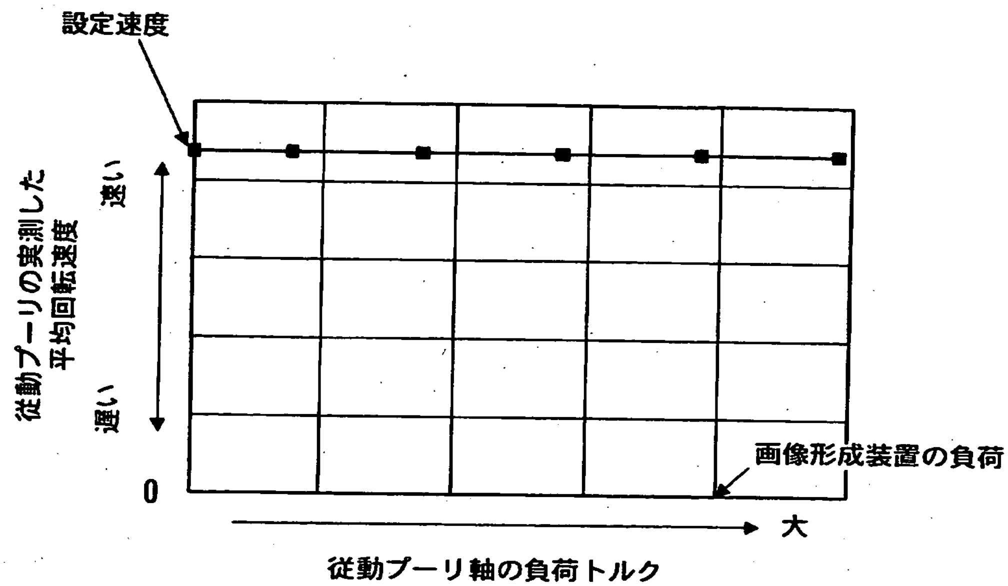

【書類名】　　要約書

【要約】

【課題】　複数の張架部材に無端状の平ベルトを掛け渡す態様において、プーリ等の張架部材と平ベルトとの間の滑りによる駆動力の伝達誤差をなくし、被駆動体に大きな負荷が係る状態であっても、駆動力を安定的に伝達する。

【解決手段】　平ベルト１の少なくとも一つには平ベルト１の進行方向に沿って複数列の貫通孔３を設け、当該平ベルト１が掛け渡される張架部材２の少なくとも一つには平ベルト１の貫通孔３が嵌合する突起４を当該張架部材２の回転方向に沿って複数列設ける。また、駆動力が伝達せしめられる張架部材２の少なくとも一つ２ａに当該張架部材２ａの回転軸に対して同軸で且つ自由回転可能な自由回転体５を設け、この自由回転体５が設けられた張架部材２ａとは異なって隣接し合う張架部材２ｂ，２ｃに対し平ベルト１を前記自由回転体５を介して掛け渡す。更に、これらの駆動力伝達装置を用いた画像形成装置をも対象とする。

【選択図】　図１

出 願 人 履 歴 情 報

識別番号　　　　　〔０００００５４９６〕

１．変更年月日　　１９９６年　５月２９日
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part of #8 (Translation of Priority paper) AADu 11/12/03

STATEMENT

I, Yoshikazu SAKA, residing at Ark Mori Building 28F, 12-32, Akasaka 1-chome, Minato-ku, Tokyo 107-6028, Japan hereby state that I have a thorough knowledge of the English and Japanese languages and that the attached documents are accurate English translations of the Japanese specification of Japanese Patent Application No.2001-157832 filed May 25, 2001 and the Japanese specification of Japanese Patent Application No.2001-281921 filed September 17, 2001, upon which the present application claims a priority.

Declared at Tokyo, Japan

This 4th day of November, 2003

Yoshikazu SAKA

PATENT OFFICE

Japanese Government

This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: May 25, 2001

Application Number: Japanese Patent Application No. 2001-157832

Applicant(s): FUJI XEROX CO., LTD.

Commissioner,

Patent Office:

(Seal)

[Name of Document]	Patent Application
[Reference Number]	FE00-02026
[Submission Date]	May 25, 2001
[Addressed To]	Commissioner, Patent Office
[International Classification]	G03G 15/01
[Title of the Invention]	DRIVING FORCE TRANSMISSION APPARATUS AND IMAGE FORMING APPARATUS USING THE SAME
[Number of Claim(s)]	10
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[Indication of Fee]

[Advance Payment Ledger Number]	011981
[Amount of Payment]	¥21,000

[List of Attached Documents]

[Article]	Specification	1 copy
[Article]	Drawings	1 copy
[Article]	Abstract	1 copy
[Collective Power of Attorney Number]	9004813	
[Collective Power of Attorney Number]	9004814	
[Collective Power of Attorney Number]	9004812	
[Request of Proof]	Requested	

[Name of Document] Specification

[Title of the Invention] DRIVING FORCE TRANSMISSION APPARATUS AND IMAGE FORMING APPARATUS USING THE SAME

[Scope of the Invention]

[Claim 1] A driving force transmission apparatus for transmitting a driving force by wearing one or plural an endless-shaped flat belts on plural tension members,

the driving force transmission apparatus characterized in that plural through holes are formed in at least one of the flat belts along a travel direction of the at least one of the flat belts; and that at least one of the tension members over which said flat belt is worn is formed plural columns of projections engaging with the through holes of the flat belt along a rotation direction of said tension member.

[Claim 2] The driving force transmission apparatus according to claim1,

the driving force transmission apparatus characterized in that the through holes adjacent to each other in a width direction perpendicular to the travel direction of the flat belt are arranged at positions where the through holes are not overlapped with each other in the travel direction of the flat belt.

[Claim 3] An image forming apparatus comprising a drive source for producing driving force; an image carrier driven by said driving force from the drive source; and a driving

force transmission apparatus for transmitting the driving force produced by said drive source to said image carrier,

the image forming apparatus characterized in that said driving force transmission apparatus comprises a plurality of tension member disposed between the drive source and the image carrier; and one or a plurality of endless-shaped flat belts worn over the plurality of tension members, and

that plural through holes are formed in at least one of the flat belts along a travel direction of the at least one of the flat belts; and that at least one of the tension members over which said flat belt is worn is formed plural columns of projections engaging with the through holes of the flat belt along a rotation direction of said tension member.

[Claim 4] A driving force transmission apparatus for transmitting a driving force by wearing one or plural an endless-shaped flat belts on plural tension members,

the driving force transmission apparatus characterized in that a free rotating member is formed on at least one of the tension members to be transmitted the driving force, the free rotating member having the same axis as a rotation axis of the at least one of the tension members and being freely rotatable, and that the flat belts are worn over adjacent tension members different from the tension member formed the free rotating member through the free rotating member.

[Claim 5] The driving force transmission apparatus

according to claim 6,

the driving force transmission apparatus characterized in that plural through holes are formed in at least one of the flat belts along a travel direction of the at least one of the flat belts; and that at least one of the tension members over which said flat belt is worn is formed plural columns of projections engaging with the through holes of the flat belt.

[Claim 6] The driving force transmission apparatus according to claim 6,

the driving force transmission apparatus characterized in that the free rotating member is positionally restricted by a position restriction member with respect to an axial direction of the rotation axis of the tension member.

[Claim 7] The driving force transmission apparatus according to claim 6,

the driving force transmission apparatus characterized in that the free rotating member includes a position regulation portion for restricting a position thereof with respect to a width direction perpendicular to the travel direction of the flat belt worn thereover.

[Claim 8] An image forming apparatus comprising a drive source for producing driving force; an image carrier driven by said driving force from the drive source; and a driving force transmission apparatus for transmitting the driving force

produced by said drive source to said image carrier,

the image forming apparatus characterized in that said driving force transmission apparatus comprises a plurality of tension member disposed between the drive source and the image carrier; and one or a plurality of endless-shaped flat belts worn over the plurality of tension members, and

that a free rotating member is formed on at least one of the tension members to be transmitted the driving force, the free rotating member having the same axis as a rotation axis of the at least one of the tension members and being freely rotatable, and that the flat belts are worn over adjacent tension members different from the tension member formed the free rotating member through the free rotating member.

[Claim 9] An image forming apparatus comprising a drive source for producing driving force; plural systems of image carriers driven by said driving force from the drive source; and a driving force transmission apparatus for transmitting the driving force produced by said drive source to said plural systems of image carriers,

the image forming apparatus characterized in that the driving force transmission apparatus according to claim 1, or 4 is used as a driving force transmission apparatus for transmitting the driving force to the system of the image carrier which is applied to the highest load among the plural systems of the image carriers.

[Claim 10]An image forming apparatus according to claim 3 or 8, the image forming apparatus comprising two systems of image carriers,

the image forming apparatus characterized in that the driving force transmission apparatus includes a first flat belt for transmitting the drive force to a first system of the image carrier from one drive source and a second flat belt for transmitting the drive force to a second system of the image carrier from the one drive source.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention belongs]

The present invention generally relates to a driving force transmission apparatus used in an image forming apparatus such as a copying machine, a printer, a facsimile, or a composite type machine made of these appliances. More specifically, the present invention relates to an improvement in such a driving force transmission apparatus for transmitting driving force by wearing, or tensioning an endless flat belt on a plurality of tension members, and also relates to an improvement in an image forming apparatus with employment of this driving force transmission apparatus.

[0002]

[Conventional Art]

Driving force transmission apparatus which are utilized

in image forming apparatus such as a printer and a copying machine own such specific characteristics that structural defects of these driving force transmission apparatus may directly induce image defects. Under such a circumstance, various sorts and higher requirements such as high engaging rates, high transmission rate, and suppression of rotation fluctuations.

In order to realize the high engaging rates and the high transmission rates, or in order to achieve the better low rotation fluctuation performance as driving force transmission apparatus of image forming apparatus according to the related art, there has been proposed a technique transmitting driving force to an image carrier by using helical gears (see, for instance, Japanese Laid-open Patent Applications No. Hei-9-80840, and No. Hei-5-72862).

Also, another technique using belts equipped with teeth has been proposed as driving force transmission member since employment of the belts equipped with teeth can realize lower rotation fluctuation performance than the employment of the helical gear.

Furthermore, in order to realize a lower rotation fluctuation than that realized by employing the belt equipped with teeth, another technique using a helical gear belt has been proposed (see, for example, Japanese Laid-open Patent Applications No. Hei-9-160332 and No. Hei-10-26903).

[0003]

In general, in the case that a helical gear is employed as a driving force transmission member, the engaging rate is made large easily, as compared with such a case that a spur gear is employed as this driving force transmission member, and also, a meshing between a drive gear and a driven gear is carried out slowly. As a result, it can be found that meshing vibrations which are transferred to this driven gear can be considerably reduced. However, in such a case that a gear is employed as such a driving force transmission member, such a technical problem cannot be avoided. Namely, rotation fluctuations are produced by a back lash.

In other words, when the drive gear is meshed, or engaged with the driven gear so as to rotary-drive this driven gear, the teeth of the drive gear is mutually made in contact with the teeth of the driven gear only for a predetermined time duration. However, after this time duration elapses, the teeth of the drive gear and the teeth of the driven gear are brought into non-contact states until the next teethes are meshed with each other, which implies a back lash (play). As a result, a back lash produces vibrations when the next teethes of these drive/driven gears are engaged with each other, and the driven gear constitutes a factor by which periodic rotation fluctuations occur (namely, engagement between teethes of gears are repeated).

This back lash cannot be in principle avoided in the case

that gears are used. In such a case that gears are employed as a driving force transmission member of an image forming apparatus, a driven gear is vibrated by such a gear engagement to be easily moved only by a movement corresponding to a back lash under non-constraint state. As a result, even such a small vibration force caused by the engagement vibration causes the periodic concentration (density) fluctuations to be produced in an output image.

[0004]

Also, even when a helical gear is employed, a total number of meshed teeth cannot be largely increased, as compared with such a case that a spur gear is used. As a consequence, when a deformation problem as to teeth is considered, the helical gear is required to be manufactured by using such a material having a certain high hardness especially in a meshing contact portion thereof.

However, in such a case that a drive gear made of a material having a high hardness is engaged with a driven gear made of a material having a high hardness, since a portion capable of absorbing vibrations produced by this gear engagement is not present in a driving force transmission path (namely, within transmission path in case that several rotating members are driven by gear train), meshing vibrations which are produced by meshing the drive gear with the driven gear are not attenuated, but are directly transferred to the driven gear. As a result,

there is another technical problem that periodic concentration fluctuations are produced in an output image.

[0005]

On the other hand, in a driving force transmission apparatus with employment of a belt equipped with teeth, since the belt equipped with the teeth which is meshed with a pulley is made of such a material as a rubber material having superior flexibility, it is so expected that vibrations produced by engaging the pulley with the belt equipped with the teeth are smaller than those produced by the gears. However, as a result of the actual measurement, there is substantially no difference between the vibrations produced by the belt equipped with the teeth and the gears, as explained as follows:

That is to say, Fig. 19 is a diagram for representing rotation fluctuations in case that both a spur gear belt and a spur gear are employed as a driving force transmission member.

As apparent from Fig. 19, even when the spur gear belt is employed, rotation fluctuation results thereof are obtained which are not different from those of the spur gear.

Apparently, a rotation fluctuation can be improved by narrowing a pitch of teeth. However, when this pitch of the teeth is excessively narrowed, a so-called "teeth skipping phenomenon" caused by an increased load occurs, so that gears cannot be actually driven. Therefore, a great improvement could not be expected. As a result, even when the spur gear

belt is employed, it is impossible to avoid an occurrence of concentration fluctuations in an output image.

[0006]

Fig. 20 represents a relationship between a concentration fluctuation allowable value and a rotation fluctuation of an image carrier drum in an image forming apparatus such as a printer.

In this drawing, such a rotation fluctuation level of the image carrier drum, at which a concentration fluctuation contained in an output image can be recognized, is equal to approximately 0.3 % in a speed variation rate of ΔV0-p (%) which constitutes an index of such a rotation fluctuation. When such a speed variation rate larger than, or equal to this fluctuation level occurs, there is a problem as to concentration fluctuations of the output image. As a consequence, the engaging vibration levels produced in the gears and the belt equipped with the teeth constitute a very serious problem in view of this concentration (density) fluctuation.

In other words, as to the rotation fluctuation requirement as the image forming apparatus, very high levels are required. Even when a helical gear belt is employed, a so-called "teeth skipping phenomenon" occurs in a similar manner to that of the spur gear belt. It is practically difficult to achieve such an improvement that the rotation fluctuation level of the spur gear belt shown in Fig. 19 is reduced lower than,

or equal to the allowable value.

[0007]

As a consequence, as the techniques according to the related arts capable of solving such a technical problem, for instance, the following driving force transmission apparatus has already been proposed (see, for instance, Japanese Laid-open Patent Application No. Hei-7-319254). That is, as a driving force transmission apparatus for moving outer peripheral planes of a plurality of image carrier drums by the same move amounts, respectively, an endless-shaped flat belt is worn between a drive pulley and a driven pulley in order to transfer the driving force.

In this type of driving force transmission apparatus, since the driving force is transferred between the flat belt and the pulley (drive pulley and driven pulley) by way of friction force, in principle, such meshing vibrations which are produced by meshing the gear with the belt equipped with the gear are not produced between the flat belt and the pulley. As a result, this technique according to the related art can effectively prevent the periodic concentration fluctuation from being produced in the output image, which occurs in such a case that the gear and the belt equipped with the gear are employed.

[0008]

[Problem to be Solved by the Invention]

However, in this sort of driving force transmission

apparatus according to the related art using the flat belt, since the driving force transmission between the flat belt and the pulley is realized by utilizing the friction transmission, another technical problem newly occurs, namely, a slip occurs between the flat belt and the pulley.

In this case, Fig. 21 is a graph indicating a relationship between an average rotation speed of a driven pulley and load torque in a driving force transmission apparatus with employment of a flat belt.

As indicated in Fig. 21, the average rotation speed of the driven pulley is rapidly lowered when the load torque exceeds a limit value. This reason is given as follows: That is, while the normal slip amount is similarly increased in connection with an increase in the load given to the driven pulley shaft (namely, driven shaft), when the load becomes larger than, or equal to a certain limit value, the slip between the flat belt and the drive pulley, or the slip between the flat belt and the driven pulley is rapidly increased, so that the average rotation speed of the driven pulley is largely lowered.

[0009]

When the driving force is transferred in the vicinity of the load amount of the driven pulley shaft under such a condition, the speed of this driven pulley is brought into unstable condition while time has passed. As a result, color shifts (color deviation) and/or transfer fluctuations occur

in an output image, so that the normal image forming operation cannot be carried out. In the worst case, the image forming apparatus is stopped or malfunctions.

Also, in order to improve the limit value of the load torque, it is advantageous to increase the belt initial tension. In other words, since the belt initial tension is increased, depression force used to depress the belt against the pulley is increased. As a result, since the friction driving force is increased, the limit value of this load torque is increased.

However, in such a case that a rubber belt and/or a resin belt is employed, rigidity of the belt itself is low, and thus, high tension cannot be applied thereto. As a result, the use of metal belts may be conceived in order to secure rigidity of a driving force transmission system and also to obtain stable driving force. However, since a friction coefficient between such a metal belt and a pulley is extremely smaller than a friction coefficient between either a rubber belt or a resin belt and a pulley, as represented in Fig. 33, a limit value of a load given to a driven pulley shaft cannot be largely improved. Even when doubled tension was applied to these rubber and resin belts, these belts could not be driven by achieving a target load amount of an image forming apparatus.

[0010]

Also, in order that a limit value of load torque is improved by employing a metal belt, in such a case that very large belt

initial tension is applied to this metal belt, shafts for supporting pulleys are flexed. As a result, the alignment of the respective pulley shafts is shifted, and the metal belt is largely meandered. Accordingly, since the flat belt was rubbed under large force with respect to the belt edge guides provided on the pulleys, distortions were produced in belt edge portions, so that the flat belt was driven under unstable condition.

As a consequence, under such a driven load condition predictable in an actual image forming apparatus, there is fatal defect, for instance, stable image forming operation cannot be realized. This metal belt employment could not also constitute the satisfactory solution.

[0011]

Furthermore, a winding angle of a belt to a pulley is increased, and whereby belt depression force given to the pulley by tension can be increased. As a result, increasing of the belt winding angle to the pulley is effective with respect to a slip of a belt.

For instance, as indicated in Fig. 22, the following technique has already been proposed, i.e., while a driving pulley (not shown) is provided in a coaxial manner with respect to a plurality of photosensitive drums 500 (500Y, 500M, 500C, 500K) as a driving force transmission apparatus for the plural photosensitive drums, a flat belt 510 is wound on this driving

pulley. In addition to both a drive tension pulley 501 and a driven tension pulley 502, several pieces of auxiliary tension pulleys 511 to 515 are provided, so that the winding angle of the flat belt 510 with respect to such a pulley for driving the photosensitive drums 500 can be secured to be large (for example, see Japanese Laid-open Patent Applications No. Hei-7-319254, No. Hei-10-111586, and No. Hei-10-161384). Incidentally, in Fig. 22, a reference numeral 505 denotes a belt unit used in an intermediate transfer operation, or used to transport paper.

However, in this type of driving force transmission apparatus, a large space is necessarily required so as to tension the belt (flat belt 510), and also, the supporting members for supporting the auxiliary tension pulleys 511 to 515 are necessarily provided. Such an arrangement is not preferably employed in view of compact/low cost aspects.

[0012]

Under such a circumstance, the Inventors of the present invention have considered such an embodiment with employment of a so-called perforation belt as a driving force transmission apparatus for, e.g., image carrier drums of a color image forming apparatus.

Figs. 23A and 23B show an outline of a driving force transmission apparatus with employment of a perforation belt. That is, a perforation belt 600 (Concretely speaking, a flat

belt 601 in which through holes 602 are arranged in a predetermined pitch interval along a circulation move direction (namely, flat belt having holes)) is worn over either a drive pulley 603 or a driven pulley 603. Projections 604 corresponding to these through holes 602 are formed on an outer peripheral plane of this pulley 603. Then, while the projections 604 of the pulley 603 are fitted to the through holes 602 of the flat belt 601, this perforation belt 600 is moved in a circulation manner.

[0013]

In such a type of driving force transmission apparatus, in comparison with the driving force transmission mode using the gear and also the belt equipped with the gear according to the related arts, respectively, there is no back lash occurred when the through holes are engaged with the projections (even when clearances are present in the through holes and the projections, since the belt itself is wound on the pulley, the non-constraint condition does not occur). The vibrations produced when the through holes are meshed with the projections can be reduced. Therefore, it is possible to prevent image defect such as periodic concentration fluctuation from occurring in the output image.

Also, the driving force is transferred by mutually engaging the projections 604 of each of the pulleys 603 with the through holes 602 of the flat belt 601. As a consequence, even when

a heavy load is applied, both the flat belt and the pulleys do not slip with each other, as compared with the case according to the related art that the driving force is transferred by using friction force exerted between the flat belt and the pulley. Therefore, it is possible to avoid an occurrence of an image defect, for example, a color shift, or color deviation, and/or an image transfer fluctuation occurs in an output image.

Fig. 24 represents a relationship between a load given to a driven pulley and an average rotation speed of the driven pulley in a driving force transmission apparatus using a perforation belt.

As understood from this drawing, since the driving force is transferred by way of the perforation belt (namely, flat belt equipped with holes), under a state that a higher load than that of the normal flat belt is applied to this perforation belt, there is no risk that the average rotation speed is lowered due to slips.

[0014]

Also, when a driving force transmission apparatus using such a perforation belt is employed, a utility possibility of a material which is used as a flat belt and a pulley can be extended. In other words, in case that the driving force is transferred by using the friction force exerted between the flat belt and the pulley in the driving force transmission apparatus according to the related art, such a material having

a higher friction coefficient (for example, resin material) must be necessarily employed. It is essentially impossible to use any materials having low friction coefficients (for instance, metal materials).

However, in this embodiment using such a perforation belt, since the driving force is transferred by mutually engaging the projections 604 of the respective pulleys 603 with the through holes 602 of the flat belt 601, more proper materials can be selected irrespective of magnitudes of friction factors.

[0015]

However, in this driving force transmission apparatus with employment of the perforation belt, the slips which are produced in the embodiment using the normal belt are prevented by engaging the through holes of the flat belt with the projections formed on the pulleys. As a result, when the heavy load torque is applied to the driven pulley shafts, the force executed in the engagement between the through holes and the projections is increased. If the thickness of this perforation belt is thin, then distortions of the through holes are increased. Therefore, there is such a phenomenon that either the hole portions of the thorough holes or the projections are destroyed. Normally, since rigid balls are used in projection portions, destruction occurs in hole portions of through holes of the perforation belt.

In this case, in order to avoid destruction of through

holes formed in a perforation belt, the following measures may be conceived. That is, a tensile load of the perforation belt is decreased by enlarging a diameter of a pulley; a thickness of this perforation belt is made thicker; and since pitch intervals of through holes and also of projections formed on the pulley are narrowed, a total number of engagements in a region where the perforation belt is wound on both a drive pulley and a driven pulley is increased.

[0016]

However, in such a case that this sort of driving force transmission apparatus is applied to color image forming apparatus and the like, which are available in recent year, since these color image forming apparatus are progressively made compact in current year, diameters of pulleys cannot be extremely increased. In connection with this technical aspect, the following technical problem occurs. That is, when the thickness of this perforation belt is made thicker, rigidity of this perforation belt is increased, so that the perforation belt cannot be wound on the pulleys having the small diameters.

Also, when the intervals of the through holes and also of the projections are gradually made narrow, the distortions occurred in the respective through holes cannot be absorbed among these through holes. As a result, the hole portions of the through holes are destroyed.

Furthermore, this destruction of the through-hole portions

is caused not only by the load torque of the driven pulley shafts, but also the belt meandering operations.

[0017]

In other words, in such a driving force transmission system by way of a perforation belt, since belt initial tension is increased similar to that of a flat belt, a load torque limit value of a driven pulley shaft can be improved. As a consequence, it is preferable to apply belt tension having a certain magnitude to this perforation belt. However, since such belt tension is applied to this perforation belt, there is a shift in alignments of the respective pulley shafts, which would cause meandering operations of the perforation belt. Although the meandering operation of the flat belt is prevented by using the guides, in accordance with the driving force transmission system by way of the perforation belt, when the clearances between the hole portions of the through holes and the projections are increased larger than the necessary clearance value, this method gives not good effects with respect to the rotation fluctuations. As a result, generally speaking, it is practically difficult to provide guides on pulleys over which the perforation belt is worn.

As a consequence, similar to the load torque given to the driven pulley shaft, the hole portions of the through holes continuously receive the force along the meander direction also by the meandering operation of the belt while this

perforation belt is driven. Since this force produced by the belt meandering operation is synthesized with force produced by the load torque along the belt rotation force, the hole portions of these through holes are brought into such a condition that these hole portions may be very easily destroyed. Further, the degrees of meandering operations are changed in response to a change in the belt tension caused by such a change in the load torque, and whereby the destruction phenomenon occurs.

[0018]

The present invention has been made to solve the above-explained technical problems, and therefore, has an object to provide a driving force transmission apparatus and an image forming apparatus with employment of this driving force transmission apparatus. That is to say, in such a driving force transmission apparatus in which an endless-shaped flat belt is worn over a plurality of tension members, while eliminating a transmission error of driving force which is caused by slips produced among the endless-type flat belt and the tension members such as pulleys, the driving force can be transferred under stable condition even under such a condition that a heavy load is given to a member to be driven.

[0019]

[Means for Solving the Problem]

As shown in Fig. 1(a), the present invention is characterized in that in a driving force transmission apparatus

for transferring driving force by wearing either one or a plurality sets of endless-shaped flat belts 1 over a plurality of tension members 2 (for example, 2a to 2d), a plurality of columns of through holes 3 are formed in at least one of the flat belts 1 along a travel direction of the flat belts 1, a plurality of columns of projections 4 engaging with the through holes 3 are provided on at least one of tension members 2 over which the flat belts 1 is worn along a rotation direction of the tension member 2.

Then, in Fig. 1(a), for example, when driving force derived from a drive source (not shown) is transferred to one tension member 2a, the driving force is transferred via this tension member 2a to the flat belt 1, and then, the driving force is transferred via this flat belt 1 to a member to be driven (not shown) which is provided in a coaxial manner to, for instance, tension members 2b and 2c.

[0020]

In such a technical means, as the endless-shaped flat belt 1, the present invention is not limited only to a single set of endless-shaped flat belt, but also to a plurality sets of endless-shaped flat belts.

Also, the tension member 2 may be selected from any member capable of tensioning the flat belt 1, and thus, may widely involve a pulley, a roller, and the like.

Furthermore, in view of stable transmissions of the driving

force, rigidity of each of members which constitute the driving force transmission apparatus is preferably selected to be high. As a result, preferably, the above-described flat belt 1 and tension member 2 is manufactured by employing such a material having a high rigidity, for example, a metal material. As a proper sort of metal materials, stainless steel is preferably employed in view of durability thereof.

Furthermore, in the flat belt 1, a plurality of through holes 3 are arrayed along a travel direction of this flat belt 1. Since the through holes 3 are fitted to the projections 4 which are formed on the rotating tension member 2, these through holes 3 are provided in a predetermined pitch interval along the travel direction of this flat belt 1.

Shapes of the projections 4 and of the through holes 3 may be arbitrarily selected. Generally speaking, considering the fitting characteristics between both the projections 4 and the through holes 3, the shapes of the projections 4 are selected to be semi-spherical, whereas the shapes of the through holes 3 are selected to be circular.

[0021]

In particular, in accordance with the present invention, a plurality of columns of the above-described through holes 3 formed in the flat belt 1 may be formed along the travel direction of the flat belt 1.

In this case, the expression "the plurality of columns

of through holes are formed along the travel direction of the flat belt 1" implies that the plurality of columns of these through holes 3 are arrayed with respect to a width direction perpendicular to the travel direction of the flat belt 1, and this array method may be arbitrarily selected.

As previously explained, when the plurality of columns of these through holes 3 are provided, even when heavy load torque is applied to shafts of the tension members 2 (for example, 2b and 2c) which are coupled to the member to be driven, the force may be received in a distribution manner by the plurality of columns of these through holes 3. Therefore, destruction occurred in portions of the through holes 3 can be effectively prevented.

[0022]

Also, as to a preferable array of these through holes 3, such through holes 3 which are located adjacent to each other with respect to the width direction perpendicular to the travel direction of the flat belt 1 is preferably arranged at such a position where these through holes 3 are not overlapped with each other with respect to the travel direction of the flat belt 1.

With this through-hole arrangement, the belt rigidity among the through holes 3 is secured, and whereby even when large tension is applied as the belt initial tension, the destruction occurred in the hole portions of the through hole

3 which is caused by the belt meandering operation can be effectively prevented.

[0023]

Furthermore, when the invention related to the above-explained driving force transmission apparatus is applied to an image forming apparatus, the following image forming apparatus is accomplished.

In other words, an image forming apparatus according to the present invention is an image forming apparatus having a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as shown in Fig. 1(a), the driving force transmission apparatus comprising a plurality of tension members 2 arranged between the drive source and the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members 2; wherein a plurality of columns of through holes 3 are formed in at least one of flat belts 1 along a travel direction of the flat belts 1; and a plurality of columns of projections 4 engaging with the through holes 3 are provided on at least one of tension members 2 over which the flat belt 1 is worn along a rotation direction of the tension member 2.

Here, as the image carrier, in addition to a photosensitive

member, an intermediate transfer member and a sheet, such as paper, transport member are included. As modes of these image carrier members, in addition to a drum-shaped (cylindrical) member, an endless-type belt member is included.

[0024]

In accordance with such an image forming apparatus, in the case that the above-described driving force transmission apparatus is applied as the image forming apparatus, in comparison with the driving force transmission mode according to the related art using the gear and the belt equipped with the gear, there is no vibration occurred when the through holes are engaged with the projections and thus it is possible to prevent such a problem that an image defect such as periodic concentration (density) fluctuation occurs in the outputs image.

Also, the driving force is transferred by mutually engaging the projections 4 of each of the tension members 2 with the through holes 3 of the flat belt 1. As a consequence, even when a heavy load is applied, both the flat belt and the pulleys do not slip, as compared with the related art in which the driving force is transferred by using friction force exerted between the flat belt and the pulley. Furthermore, even when a larger load is given, there is no risk that the hole portions of the through holes 3 are not destroyed. Therefore, it is possible to prevent an occurrence of an image defect, for example, a color shift, or color deviation, and/or an image transfer

fluctuation occur in an output image. Thus, the stable image forming operation may be carried out.

[0025]

Moreover, in view of energy saving aspect and cost reduction aspect, there is such a trend that the rotation loads given to the image carriers are increased in the below-mentioned cases: that is, not only such image carriers, but also rotation members such as a transfer roller and an electrostatic charging roller are rotary-driven by a single drive source, while these rotation members are rotary-driven in contact with the image carriers; and in order to reduce a total number of components, slide bearings are employed instead of roller bearings as to the bearings used for these image carriers and other rotation members. As a consequence, the present invention is preferably applied to such an image forming apparatus.

[0026]

Also, there are such image forming apparatus equipped with a plurality of systems of image carriers among image forming apparatus.

In this case, in order to avail merits of the present invention, that is, even when the rotation load is large, no slip occurs between the flat belt 1 and the tension members 2 such as the pulleys; the destruction of the hole portions of the through holes 3 formed in the flat belt 1 can be prevented; and no image defect is produced, for example, neither color

shifts, nor transfer fluctuations occur in output images, the present invention is preferably applied to the plurality of systems of image carriers to which heavier rotation loads are applied.

In such a case, an image forming apparatus of the present invention is realized by such an image forming apparatus comprising: a drive force for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, the driving force transmission apparatus shown in Fig. 1 may be employed as such a driving force transmission apparatus capable of transferring the driving force to a system of an image carrier, in which the largest rotation load is applied, among plural systems of image carriers.

In this embodiment, the expression "driving force transmission apparatus capable of transferring driving force to system of image carrier, the rotation load of which is the largest load" implies such a driving force transmission system provided for a subject image carrier in such an assumption that there are plural image carriers belonging to a certain system, and driving force transmission systems for the respective image carriers are provided in a parallel manner. Also, this "driving force transmission apparatus" implies an entire driving

force transmission system for a plurality of image carriers which contain such an image carrier having the largest rotation load in such an assumption that there are plural image carriers belonging to a certain system, and driving force transmission systems for the respective image carriers are provided in a series manner.

[0027]

Furthermore, in such a case that a plurality of systems of image carriers are rotary-driven by a single drive source, there is such a risk that disturbance applied to one system of image carriers may give an influence to another image carrier. As this disturbance, the following cases are conceivable. For instance, a cleaning apparatus is made in contact with a transfer apparatus, and/or is separated from this transfer apparatus, and an article rides over a recording sheet, and/or ride down this recording sheet.

In such a case, in an image forming apparatus equipped with two systems of image carriers, according to the present invention, a driving force transmission apparatus may comprise: a first flat belt for transferring driving force from one drive source to a first system of an image carrier; and a second flat belt for transferring driving force from one drive source to a second system of an image carrier.

Since the image forming apparatus is configured in such a manner, even in a case that certain disturbance is applied

to the first system of the image carrier and then this disturbance is transferred via the first flat belt to the drive source, the drive source may cancel this disturbance based upon its characteristic, so that this disturbance is not transferred via the second flat belt to the second system of the image carrier. As to this characteristic of the drive source, concretely speaking, while the drive source produces the drive torque (namely, summation of load torque applied to both first flat belt and second flat belt) from the own drive source to rotate, the disturbance is penetrated through a large DC torque generating source, by which an adverse influence with respect to this disturbance may become small, rather than such a case that a driven pulley directly receives disturbance (torque variation) from a flat belt, since the holding power of the drive source is made effective. Conversely, when the disturbance is applied to the second system of the image carrier, a similar effect may be achieved.

[0028]

In this case, various embodiments may be conceived as to a relationship of two systems of image carriers: That is, for example, 1) the first system of the image carrier directly contacts with the recording sheet, but the second system of the image carrier does not directly contact with this recording sheet; 2) a color of a toner image held on the image carrier surface belonging to the first system is different from a color

of a toner image held on the image carrier surface belonging to the second system; 3) the cleaning apparatus does not abut, but also is not separated from the first system of the image carrier, whereas the cleaning apparatus abuts, and is separated from the second system of the image carrier; 4) the transfer apparatus does not abut, but also is not separated from the first system of the image carrier, whereas the transfer apparatus abuts, and is separated from the second system of the image carrier; and also 5) both the cleaning apparatus and the transfer apparatus abut and are separated from the first and second systems of these image carriers at different timing.

[0029]

Also, a driving force transmission apparatus, according to another aspect of the present invention, is featured by such a driving force transmission apparatus for transferring driving force by wearing either one or a plurality of endless type flat belts 1 over a plurality of tension members 2 (for example, 2a to 2c), as indicated in Fig. 1(b), in which a free rotating member 5 is provided on at least one (for example 2a) of these tension members 2 to which the driving force is transferred in such a manner that the free rotating member 5 is freely rotatable, and is arranged in a coaxial manner with respect to a rotation shaft of this tension member 2a; and the flat belt 1 is worn via the free rotating member 5 over tension members 2 (for example, 2b and 2c) which are different

from the tension member (for example, 2a) on which this free rotating member 5 is provided, and are located adjacent to each other.

[0030]

Then, in Fig. 1(b), when the driving force is transferred to the tension member 2 (for example, 2a), the driving force is transferred via this tension member 2a to the flat belt 1, and then, the driving force is transferred via this flat belt 1 to a member to be driven (not shown) which is provided in a coaxial manner to, for example, the tension members 2b and 2c.

At this time, since the flat belt 1 is worned via the free rotating member 5 with respect to the tension members 2b and 2c, the winding angle of this flat belt 1 with respect to the tension members 2b and 2a may be secured as a sufficiently large winding angle, and also the friction resistance between this flat belt 1 and the tension members 2b/2c to which the driven member is coupled may become sufficiently high friction resistance. Thus, the driving force derived from the flat belt 1 may be firmly transferred to the tension members 2b and 2c.

On the other hand, since the free rotating member 5 is freely rotatably provided on the rotation shaft of the tension member 2 (for example, 2a) in a coaxial manner, there is no necessity for especially securing the setting space of the

free rotating member 5.

As a consequence, the extra members for conventionally supporting the auxiliary tension pulley, and also the specific space are not required. Also, the winding angle of the flat belt 1 can be set to a sufficiently large winding angle with respect to the tension members 2 (for example, 2b and 2c) to which the driving member is coupled.

[0031]

In such a technical means, as the flat belt 1, the present invention is not limited only to a single set of flat belt, but also to plural sets of flat belts. Also, the tension member 2 may widely involve a pulley, a roller, and the like.

In this case, the expression "tension member 2 (for example, 2a) to which driving force is transferred" implies that the tension member 2 may be directly coupled to the drive source, or the tension member 2 may be driven by another drive transmission system.

Furthermore, the expression "free rotating member 5" implies such a member which can be freely rotated and must be provided in a coaxial manner with respect to the rotation shaft of the tension member 2 (for example, 2a) to which the drive force is transferred, and may widely involve a bearing, a collar, and the like.

[0032]

Also, in the mode shown in Fig. 1(b), the flat belt 1

may involve the normal belt. Alternatively, in view of effectively avoiding the slip produced between the flat belt 1 and the tension member 2, the following modification mode may be preferably employed. That is, while either one column or plural columns of through holes (not shown) are formed in at least one of flat belts 1 along a travel direction of this flat belt, projections (not shown) which are fitted to the through holes of the flat belt 1 are provided on at least one of tension members 2 over which this flat belt 1 is worn.

In accordance with such a modification mode, since the winding angle of the flat belt 1 with respect to the tension member 2 can be made large, the force which is exerted to the through-hole portions fitted to these projections can be distributed, and the destruction of these through hole portions can be effectively prevented.

[0033]

Furthermore, when the free rotating member 5 is moved along the rotation shaft direction of the tension member 2, since the flat belt 1 which is worn over this free rotating member 5 is meandered, it is preferable to restrict the position of this free rotating member 5 along the shaft direction, in view of such a technical aspect that the meandering operation of the flat belt 1 is effectively prevented.

In this case, the free rotating member 5 may be positionally restricted by a position restriction member (not shown) with

respect to the shaft direction of the rotation shaft of the tension member 2.

Furthermore, even when the free rotating member 5 itself is positionally restricted along the shaft direction, there is such a risk that the flat belt 1 itself which is worn over the free rotating member 5 is meandered. In view of such a technical aspect capable of effectively preventing the occurrence of such a belt meandering operation, it is preferable that a position of the free rotating member 5 is restricted in an axial direction.

The expression "position restricting portion" may widely involve projections which are fitted to through holes if the flat belt 1 is equipped with the through holes, and also a restriction wall capable of preventing the meandering operation of the flat belt 1.

[0034]

Furthermore, when the inventive idea related to the above-explained driving force transmission apparatus is applied to an image forming apparatus, the following image forming apparatus may be accomplished.

In other words, an image forming apparatus, according to the present invention, is featured by such an image forming apparatus comprising: a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force

transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as represented in Fig. 1(b), in which: the driving force transmission apparatus is comprised of: a plurality of tension members 2 (for example, 2a to 2c) arranged between the drive source and the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members 3; a free rotating member 5 which is freely rotatable and is arranged in a coaxial manner with respect to a rotation shaft of one tension member (for example, 2a) among the tension members 2 is provided on at least one tension member 2a, to which the driving force is transferred; and also the flat belt 1 is worn via the free rotating member 5 with respect to such tension members 2 (for example, 2b and 2c) which are located adjacent to each other, and are different from the tension member 2a where this free rotating member 5 is provided.

[0035]

In accordance with such an image forming apparatus, the driving force transmission apparatus indicated in Fig. 1(b) can secure the large winding angle of the flat belt 1 with respect to a plurality of tension members 2 without unnecessarily enlarging the layout space, and also can reduce the transmission error of the driving force. As a consequence, while this image forming apparatus can satisfy the requirements of compact/low

cost aspects, it is possible to avoid an occurrence of an image defect, for example, a color shift, or color deviation, and/or an image transfer fluctuation occurred in an output image. Thus, the stable image forming operation may be carried out.

Moreover, in view of energy saving aspect and also cost reduction aspect, there is such a trend that the rotation loads given to the image carriers are increased in the below-mentioned cases: That is, not only such image carriers, but also rotation members such as a transfer roller and an electrostatic charging roller are rotary-driven by a single drive source, while these rotation members are rotary-driven in contact with the image carriers; and in order to reduce a total number of components, slide bearings are employed instead of roller bearings as to the bearings used for these image carriers and other rotation members. As a consequence, the inventive idea of the present invention may be preferably applied to such an image forming apparatus.

[0036]

Also, there are such image forming apparatus equipped with plural systems of image carriers among image forming apparatus. In this case, the inventive idea of the present invention may be preferably applied to plural systems of image carriers to which heavier rotation loads are applied similar to the image forming apparatus into which the driving force transmission apparatus shown in Fig. 1(a) has been assembled.

In such a case, an image forming apparatus of the present invention may be realized by such an image forming apparatus comprising: a drive force for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, the driving force transmission apparatus shown in Fig. 1(b) may be employed as such a driving force transmission apparatus capable of transferring the driving force to a system of an image carrier, in which the largest rotation load is applied, among plural systems of image carriers.

Furthermore, in the case that two systems of image carriers are rotary-driven by a single drive source, an image forming apparatus, according to the present invention, may be realized by that in an image forming apparatus equipped with two systems of image carriers, a driving force transmission apparatus may be comprised of: a first flat belt for transferring driving force from one drive source to a first system of an image carrier; and a second flat belt for transferring driving force from one drive source to a second system of an image carrier.

[0037]

[Embodiment of the Invention]

Referring now to the accompanying drawings, the present invention will be described in detail.

O Embodiment 1

Fig. 2 is a sectional diagram for schematically representing an embodiment 1 of a copying machine (image forming apparatus) 80 to which the present invention is applied.

In this drawing, an arrangement of this copying machine 80 will now be explained, while this arrangement is subdivided into an image input system, an image forming system, and a sheet transporting system.

The image input system is provided with an original mounting base 70 on which an original is mounted, an original reading apparatus 71 for reading the original mounted on this original mounting base 70, and an image processing apparatus 72 for processing image information read by this original reading apparatus 71.

The image forming system is provided with an image forming station 10, an exposing apparatus 13, two first intermediate transfer drums 31, and one second intermediate transfer drum 32. The image forming stations 10 (concretely speaking, reference numerals 10K, 10Y, 10M, 10C, namely, portions surrounded by dotted lines in this drawing) correspond to each of black, yellow, magenta, and cyan colors. The exposing apparatus 13 (concretely speaking, reference numerals 13K to 13C) expose the image forming stations 10 in response to image data supplied from the image processing apparatus 72. Images formed in the respective image forming stations 10 are

sequentially transferred to and held on the two first intermediate transfer drums 31 (concretely speaking, reference numerals 31a and 31b).

[0038]

In this case, each of the image forming stations 10 is equipped with electrophotographic devices such as a photosensitive drum 11 (concretely speaking, reference numerals 11K to 11C), a charging apparatus 12 (concretely speaking, reference numerals 12K to 12C) charging the photosensitive drum 11, a developing apparatus 14 (concretely speaking, reference numerals 14K to 14C) developing a latent image written on the charged photosensitive drum 11 by using the exposing apparatus 13by using the respective color toners and the like.

Incidentally, (primary) transferring apparatus (not shown) are arranged at portions where the respective photosensitive drums 11 (11K to 11C) and the first immediate transfer drums 31a and 31b face to each other and (secondary) transferring apparatus (not shown) are provided at portions where the first intermediate transfer drums 31a and 31b and the second intermediate transfer drum 32 face to each other.

[0039]

Furthermore, the sheet transporting system is provided with a sheet tray 40 on which recording sheets such as paper are stacked/mounted, a pick-up roller 41 for picking up the recording sheets in the sheet tray 41 one by one, a register

roller 42 for positioning the picked-up recording sheets, a (thirdly) transfer roller 43 for transferring the image on the second intermediate transfer drum onto the recording sheets, a fixing roller 44 for fixing the image transferred onto the recording sheets, and an ejection tray 45 for storing thereinto the ejected recording sheet.

[0040]

Next, a description will now be made of basic full-color copying operations of such a copying machine 80.

First, when a user mounts an original to be read on the original mounting base 70, and then, instructs a full-color copying operation by using a user interface (not shown), the image reading apparatus 71 scans this original so as to optically read the content of this scanned original, and then, converts the read original content into an electric signal (image data "I"). This image data I is color-separated into a black color, a yellow color, a magenta color, and a cyan color in the image processing apparatus 72. Also, this image processing apparatus 72 performs such an image processing operation that a predetermined weighting factor in which a characteristic of marking device/process is taken into consideration is applied to the image data "I (namely, IK, IY, IM, IC)" having these colors.

[0041]

On the other hand, the photosensitive drums 11 employed

within the respective image forming stations 10 are rotary-driven by a belt driving apparatus 100 (see Fig. 3 and Fig. 4, will be explained later) along directions indicated by arrows as shown in this drawing. The surfaces of these photosensitive drums 11 are uniformly charged at a predetermined potential by the charging apparatus 12. Then, the respective exposing apparatus (13K to 13C) expose exposure light corresponding to the respective image data I(IK to IC) onto the surfaces of the respective photosensitive drums 11 (11K to 11C) at predetermined timing, so that latent images are formed by potential differences on the surfaces of the respective photosensitive drums 11 (11K to 11C). The latent images are converted into toner images "T" (K, Y, M, C) in such a manner that the toners are electrostatically adhered onto these latent images by the respective developing apparatus 14 (14K to 14C).

[0042]

On the other hand, both the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32 are rotary-driven by the belt driving apparatus 100 (see Fig. 3 and Fig. 4, will be explained later) along directions indicated by arrow, as shown in this drawing. Then, this toner image T(K, Y) is electrostatically transferred from the photosensitive drum 11 (11K, 11Y) to the first intermediate transfer drum 31a by a primary transferring apparatus (not shown) and the toner image T(M, C) is electrostatically transferred (primary

transfer) from the photosensitive drum 11 (11M, 11C) to the first intermediate transfer drum 31b. In this case, the toner image T(K, Y) is superimposed with each other on the surface of the first intermediate transfer drum 31a and the toner image T(M, C) is superimposed with each other on the surface of the first intermediate transfer drum 31b.

[0043]

Furthermore, the toner image T(KY) superimposed with each other on the first intermediate transfer drum 31a is electrostatically transferred (secondary transfer) to the second intermediate transfer drum 32 by a secondary transferring apparatus (not shown), and similarly, the toner image (MC) superimposed with each other on the first intermediate transfer drum 31b is electostatically transferred to this secondary intermediate transfer drum 32. In this case, the toner image T(KY) is superimposed with the toner image T(MC) on the surface of the second intermediate transfer drum 32, so that a full-colored toner image (KYMC) is formed thereon.

As explained above, while the toner image T(KYMC) is formed, one sheet of the recording sheet "S" stored in the sheet tray 40 is picked-up by the pick-up roller 41, and then, is transported to the register roller 42. For instance, the register roller 42 starts to be rotated from the stop condition up to predetermined timing, whereby a timing when the full-colored toner image T(KYMC) electrostatically formed on the second intermediate

transfer drum 32 is reached to a nip portion (not shown) with respect to the transfer roller 43 coincident with another timing when the recording sheet S is reached to this nip portion. Thus, the full-colored toner image T(KYMC) formed on the second intermediate transfer drum 32 is electrostatically transferred to the recording sheet S.

Thereafter, when the recording sheet S passes through the nip portion of the fixing roller 44, while the full-colored toner image T(KYMC) is electrostatically held on the surface of this recording sheet S, this full-colored toner image T(KYMC) is fixed on this surface by receiving heat (thermal energy) and pressure given from the respective fixing rollers 44 and also effects thereof, and then, the recording sheet S on which the full-colored toner image has been fixed is ejected to the ejection tray 45 provided outside the copying machine 80.

While such a series of copying steps is defined as one cycle, this copy cycle is continuously carried out, so that full-colored images can be successively copied.

[0044]

Fig. 3 is a perspective view showing the belt driving apparatus 100 which drives this copying machine 80. This drawing shows a structure of this belt driving apparatus 100, as viewed from a rear surface side of Fig. 2. Incidentally, Fig. 4(a) is an explanatory diagram showing a front view of the belt driving apparatus 100 of Fig. 3, and Fig. 4(b) is an explanatory

diagram showing a plan view thereof.

In the drawings, the belt driving apparatus 100 is employed so as to drive the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a, 31b, and also the second intermediate transfer drum 32. This belt driving apparatus 100 is provided with two flat belts 101/102, and various sorts of tension members on which these flat belts 101 and 102 are tensioned, or worn.

In this case, as the above-described tension member, there are driven pulleys 111 to 117, and tension pulleys 121 and 122 for circulating the respective flat belts 101/102. The driven pulleys 111 to 117 are mounted on one ends of the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32 along axial directions thereof.

Incidentally, in this embodiment, the driven pulley 117 mounted on the second intermediate transfer drum 32 owns a two-stage belt hanging plane over which the first flat belt 101 and the second flat belt 102 are hung, respectively.

[0045]

Then, the first flat belt 101 is hung over the tension pulley 121, the driven pulleys 111 to 114 which are mounted on the axes of the respective photosensitive drums 11 (11K to 11C), and the driven pulley 117 which is mounted on the axis of the second intermediate transfer drum 32.

On the other hand, the second flat belt 102 is hung over the tension pulley 122, the driven pulleys 115 and 116 which are mounted on the axes of the first intermediate drums 31a/31b, and the driven pulley 117 which is mounted on the axis of the second intermediate transfer drum 32.

Incidentally, pulley shafts (not shown) provided with the respective pulleys 111 to 117, 121, and 122 are supported by respective slide bearings which are provided on side surfaces of the copying machine 80, and therefore, these pulley shafts can be freely rotated.

[0046]

In this case, the way how to apply power derived from a driving motor (drive source, i.e., not shown) to which shaft is that it is preferable to employ such configuration that the driving force derived from the driving motor is inputted to a pulley shaft having large winding angles between flat belts and pulleys.

In this embodiment, for instance, the driving force derived from the driving motor may be set to be inputted to the shaft of the second intermediate transfer drum 32. Alternatively, the driving force derived from the driving motor may be inputted to another pulley shaft.

Resin materials may be employed as manufacturing materials of these flat belts 101 and 102. However, metal materials such as stainless steel, nickel, and titanium are preferably

used in view of durability and processing precision etc. More specifically, stainless steel is more preferably employed in view of cost, durability, and mechanical strengths etc.

Similarly, resin materials may be employed as manufacturing materials of these pulleys, however, metal materials such as stainless steel, aluminum, and carbon steel are preferably used in view of durability and processing precision etc. More specifically, generally speaking, a pulley made of a metal owns larger inertia moment, as compared with a pulley made of resin. As a result, this metal pulley may expect an attenuation effect with respect to high frequency vibrations such as mesh vibrations, which may induce a problem, i.e., image defect of an image outputted from an image forming apparatus. In view of this attenuation effect, a metal material is preferably employed as this pulley material. In particular, a stainless steel is more preferably employed as this pulley material among the metal materials in view of these cost, durability, and mechanical strengths.

[0047]

Fig. 5 is an explanatory diagram showing structures of a flat belt and a pulley more in detail.

In this case, the flat belts 101/102 and the respective pulleys 110 (namely 111 to 117, 121, 122), which are employed so as to drive the intermediate transfer drums of Fig. 2, will now be described as an example.

A not shown cleaner abuts against the first intermediate transfer drums 31a and 31b shown in Fig. 2, and thus, a relatively heavier load is given to these first intermediate transfer drums, as compared with other drums. As a consequence, in this embodiment, plural columns (three columns in this example) of through holes 130 are formed in the first and second flat belts 101 and 102 along travel directions thereof. Also, plural columns (three columns in this example) of projections 140 are formed on either all or a portion of these pulleys 110 (a case of all pulleys is illustrated in this example). These projections 140 are located in correspondence with the through holes 130 of the flat belts 101 and 102. Since the projections 140 of the pulley 110 are fitted to the through holes 130 of the flat belts 101/102, the stable driving operations of the flat belts 101/102 is realized.

In this embodiment, for example, circular holes are employed as the through holes 130 and semi-spherical-shaped projections are used as the projections 140.

[0048]

In this embodiment shown in Fig. 5(a), 5(b), 5(c), the pitches of these through holes 130 along all of the columns are set to the same intervals (equi-interval) in the flat bets 101 and 102. However, the present invention is not limited thereto, but the intervals may be changed in the respective columns. Also, among the three columns of through holes, a

pitch "p" of a central column of the through holes 130b is made equal to pitches "p" of both side columns of the through holes 130a and 130c. However, a phase "θ" is shifted by 180 degrees.

This phase-shift setting is intended so as to avoid destruction of through-hole portions which are caused by belt meanders (will be explained later).

Also, in this embodiment, while the plural columns of through holes 130 are formed in the flat belts 101 and 102, the plural columns of projections 140 are formed in correspondence with the above-explained through holes 130 in the pulley 110. However, these projections 140 need not be provided in correspondence with all of these through holes 130, but may be provided on at least a pulley 110 having the largest load.

As a result, the projections 140 need not be fitted to all of the columns of these through holes 130, but may be fitted only to one column among the three columns thereof. Alternatively, the pitch of these projections 140 may be made equal to a pitch larger than the through-hole pitch multiplied by an integer. As a result, the fitting specifications of the flat belts 101/102 in which the plural columns of through holes 130 are formed, and also, the fitting specifications of the several pulleys 110 around which the flat belts 101 and 102 are wound may be freely designed every use case.

[0049]

Fig. 6(a) and Fig. 6(b) shows a summary of effects with respect to the load of the structure of the image forming apparatus according to this embodiment, and Fig. 6(c) and Fig. 6(d) shows a summary of effects with regard to the belt meandering operations thereof more in detail.

Fig. 6 shows both a perforation belt moved in a circulation manner along a direction indicated by an arrow (namely, flat belt equipped with through holes) and projections which are provided on a pulley and are fitted to through holes formed in this flat bet.

Fig. 6(a) shows a drive condition in a comparison mode (flat belts 101' and 102') in which one column of through holes 130' are formed. In a case of a heavy load, as indicated in this drawing, the flat belts 101' and 102' are moved along a direction opposite to the circulation direction of the through holes 130', so that a distortion is produced at portions where these through holes 130' are engaged with the projections 140'. When a magnitude of this distortion becomes larger than, or equal to a certain magnitude, a belt portion of the through hole 130' is destroyed, so that the belt drive operation is brought into unstable drive operation.

In order to reduce adverse influences of this distortion to drive the belts under stable conditions, in this embodiment, as shown in Fig. 6(b), plural columns of through holes 130

are formed in the flat belts 101 and 102 with respect to circulation directions. As a result, a distortion occurred in a portion of one through hole 130 when the pulley 110 to which a heavy load is given is driven can be reduced, and thus, driving force can be transferred under stable condition.

[0050]

Fig. 6(c) showns a modification mode in which the plural columns of through holes 130 are formed in the flat belts 101 and 102 to have the same phase condition in this embodiment. In this case, similar effects to those of Fig. 6(b) may be achieved with respect to a load, and thus, a distortion occurred per a single hole portion of the through hole 130 may be reduced. However, under such a condition that belt meandering operations are produced, the pitches of the hole portions of the through holes 130 with respect to the meander direction are excessively narrowed, so that there is no region capable of absorbing distortions, which may readily conduct destruction of hole portions of these through holes 130.

To avoid this problem, when the belt meander direction is considered, as explained in this embodiment, it is preferable to employ a belt structure as indicated in Fig. 6(d).

To this end, in the case that widths of flat belts are made sufficiently wide, since pitches of plural columns of through holes along the meander direction is large, there is no problem even if the belt structure of Fig. 6(c) is employed.

However, in the case that a compactness of an apparatus such as an image forming apparatus is required, it is preferable to employ such a belt structure shown in Fig. 6(d). As a consequence, since the belt structures as indicated in Fig. 4(b) and Fig. 4(d) are employed in this embodiment, the stable belt driving operations can be realized.

[0051]

Therefore, in accordance with this embodiment, there is no risk that the hole portions of the through holes 130 formed in the flat belts 101 and 102 are destroyed, and furthermore, the driving force derived from the drive motor can be firmly transferred to the photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32.

This fact is proved in an example 1 (will be discussed later).

[0052]

More specifically, in the technical field of color image forming apparatus which have been currently and advantageously developed, in order to reduce electric power consumption and manufacturing cost, a drive system is required in which not only photosensitive drums, but also intermediate transfer drums and intermediate transfer belts, and furthermore, transfer rollers and charge rollers are driven by a single drive motor. There is such a trend that load torque is gradually increased,

and driving force transfer members should endure this increased load torque to realize color image forming operations.

In addition, in order to reduce cost of parts, there are many possibilities that as to bearings for supporting rotation shafts of respective image carrier drums, roller bearings which have been conventionally used are replaced by slide bearings. Under such a bearing change environment, load torque would be increased by replacing these roller bearings with these slide bearings.

This embodiment can achieve very large effects even under such a requirement. This merit may be similarly achieved in the below-mentioned embodiments.

[0053]

Incidentally, in this first embodiment, as the belt driving apparatus 100, such a belt driving apparatus has been employed which is constituted by the two flat belts 101 and 102, and the pulleys 110 (111 to 117, 121, 122) for hanging these flat belts. However, the present invention is not limited to this belt driving apparatus, but may be applied to another belt driving apparatus as shown in Fig. 7. That is, while this belt driving apparatus 100 is equipped with a single flat belt 103, and pulleys (namely, driven pulleys 111 to 117, and tension pulley 121) for hanging this single flat belt 103, for example, the driving force derived from the drive motor may be applied to the driven pulley coupled to the second intermediate transfer

drum 32, and also this driving force may be transferred to the respective pulleys 110 via the single flat belt 103 which is hung over the respective pulleys 110 so as to drive the photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32.

[0054]

O Embodiment 2

Fig. 8 is a sectional diagram for schematically representing an embodiment 2 of a copying machine (image forming apparatus) 90 to which the present invention is applied.

In this drawing, an arrangement of this copying machine 90 will now be explained, while this arrangement is subdivided into an image input system, an image forming system, and a sheet transporting system.

The image input system is provided with an original mounting base 70, an original reading apparatus 71, and an image processing apparatus 72.

The image forming system is provided with an image forming station 10, an exposing apparatus 13, two first intermediate transfer drums 31, and one second intermediate transfer drum 32. The image forming stations 10 (concretely speaking, reference numerals 10K, 10Y, 10M, 10C, namely, portions surrounded by dotted lines in this drawing) correspond to each of black, yellow, magenta, and cyan colors. The exposing

apparatus 13 (concretely speaking, reference numerals 13K to 13C) expose the image forming stations 10 in response to image data supplied from the image processing apparatus 72.

In this case, the image forming stations 10 (10K to 10C) is equipped with electrophotographic devices such as a photosensitive drum 11 (concretely speaking, reference numerals 11K to 11C), a charging apparatus 12 (concretely speaking, reference numerals 12K to 12C), a developing apparatus 14 (concretely speaking, reference numerals 14K to 14C), a drum cleaner 15 (concretely speaking, reference numeral 15K to 15C), and a transfer roller 22 (concretely speaking, reference numerals 22K to 22C). The charging apparatus 12 charges the photosensitive drum 11. The developing apparatus 14 develops a latent image written on the charged photosensitive drum 11 by using the exposing apparatus 13, by using the respective color toners. The drum cleaner 15 cleans toners left on the photosensitive drum 11. The transfer roller 22 transfers an image formed on the photosensitive drum 11 to the recording sheet "S."

In particular, in this embodiment, the photosensitive drums 11 (reference numbers 11K to 11C) are driven by belt driving apparatus 50 (concretely speaking, reference numerals 50K to 50C), respectively. In the belt driving apparatus 50 (reference numerals 50K to 50C), driving force derived from a single drive motor is supplied via an entire belt driving

apparatus (not shown) to the driving force transfer shafts of each of belt driving apparatus 50.

[0055]

Further, the sheet transporting system is provided with a sheet transporting belt 20, and a fixing roller 44, and so on. This sheet transporting belt 20 transports a recording sheet "S" in correspondence with each of the image forming stations 10 (reference numerals 10K to 10C) and is positioned at a post stage of a register roller 42. The fixing roller 44 is provided at a post stage of this sheet transporting belt 20.

Then, in this embodiment, the sheet transporting belt 20 is tensioned and worn over a plurality of tension rollers 24 (reference numerals 24a to 24e) including at least a driving roller 24a. Around this sheet transporting belt 20, there are provided a belt cleaner 26, a belt erasing apparatus 27, a sucking electrostatic charging apparatus 28, and a stripping electrostatic charging apparatus 29. The sucking electrostatic charging apparatus 28 sucks and holds the recording sheet "S" onto the sheet transporting belt 20. The stripping electrostatic charging apparatus 29 stripes the recording sheet "S" from the sheet transporting belt 20.

[0056]

Next, a description will now be made of basic full-color copying operations of such a copying machine 80.

First, when a user mounts an original to be read on the original mounting base 70, and then, instructs a full-color copying operation by using a user interface (not shown), the image reading apparatus 71 scans this original so as to optically read the content of this scanned original, and then, converts the read original content into an electric signal (image data "I"). This image data I is color-separated into a black color, a yellow color, a magenta color, and a cyan color in the image processing apparatus 72. Also, this image processing apparatus 72 performs such an image processing operation that a predetermined weighting factor in which a characteristic of a marking device/process is taken into consideration is applied to the image data "I (namely, IK, IY, IM, IC)" having these colors.

[0057]

On the other hand, the photosensitive drums 11 employed within the respective image forming stations 10 are rotary-driven by a belt driving apparatus 50 (reference numerals 50K to 50C) along directions indicated by arrows as shown in this drawing. The surfaces of these photosensitive drums 11 (reference numerals 11K to 11C) are uniformly charged at a predetermined potential by the charging apparatus 12 (reference numerals 12K to 12C). Then, the respective exposing apparatus 13 (13K to 13C) expose exposure light corresponding to the respective image data I(IK to IC) onto the surfaces of the respective

photosensitive drums 11 (11K to 11C) at predetermined timing, so that latent images are formed by potential differences on the surfaces of the respective photosensitive drums 11 (11K to 11C). The latent images are converted into toner images "T" (K, Y, M, C) in such a manner that the toners are electrostatically adhered onto these latent images by way of the respective developing apparatus 14 (14K to 14C).

[0058]

As explained above, while the toner image T (K, Y, M, C) is formed, one sheet of the recording sheet "S" stored in a sheet tray (not shown) is picked-up by a pick-up roller 41 (not shown), and then, is transported to the register roller 42. For instance, since the register roller 42 starts to be rotated from the stop condition up to predetermined timing, the recording sheet "S" is transferred to the sheet transporting belt 20 which is rotary-driven by a driving apparatus (not shown) along a direction denoted by an arrow of this drawing.

Incidentally, while the recording sheet "S" is transferred from the register roller 42 to the sheet transporting belt 20, electron charges are applied from the sucking electrostatic charging apparatus 28 to the sheet transporting belt 20 in such a manner that this recording sheet "S" is sucked to the sheet transporting belt 20.

[0059]

Then, the toner images T (K, Y, M, C) formed on the

photosensitive drums 11 (11K to 11C) are sequentially transferred from the respective photosensitive drums 11 (11K to 11C) onto the sheet transporting belt 20 by the transfer roller 22 (22K to 22C) in an electrostatic manner. In this case, the toner image T(K) is firstly transferred (primary-transferred) onto the recording sheet "S", the toner image T(Y) is transferred onto this toner image T(K), and then, the toner image T(M) is transferred onto this toner image T(Y), and furthermore, the toner image T(C) is superimposed onto this toner image T(M) in a sequential manner. As a result, a full-colored toner image T (K, Y, M, C) is formed.

Incidentally, articles such as toners which are partially left on the surfaces of the respective photosensitive drums 11 (11K to 11C) after the primary transfer operation is eliminated by drum cleaners 15 (reference numerals 15K to 15C). Also, articles such as toners which remain on the surface of the sheet transporting belt 20 is removed by the belt cleaner 26. Furthermore, potential histories which are left on the sheet transporting belt 20 is eliminated by the belt erasing apparatus 27.

[0060]

Thereafter, when the recording sheet S passes through the nip portion of the fixing roller 44, while the full-colored toner image T (K, Y, M, C) is electrostatically held on the surface of this recording sheet S, this full-colored toner

image T (K, Y, M, C) is fixed on this surface by receiving heat (thermal energy) and pressure given from the respective fixing rollers 44 and also effects thereof, and then, the recording sheet "S" on which the full-colored toner image has been fixed is ejected to the ejection tray 45 provided outside the copying machine 90.

In this case, when the recording paper "S" is transferred from the sheet transporting belt 20 to the fixing roller 44, such electron charges are applied by the stripping electrostatic charging apparatus 29 to the recording sheet "S", by which this recording sheet "S" is stripped from the sheet transporting belt 20.

While such a series of copying steps is defined as one cycle, this copy cycle is continuously carried out, so that full-colored images can be successively copied.

[0061]

Similar to the embodiment 1, when both the flat belt equipped with plural columns of holes and the pulley equipped with projections are applied to the respective belt driving apparatus 50 (50K to 50C) and the entire belt driving apparatus, which are employed so as to drive the respective photosensitive drums 11 (11K to 11C) of the copying machine 90, both operations and effects similar to those of the embodiment 1 can be achieved.

Also, a belt driving apparatus similar to that of the embodiment 1 may be also applied to the driving apparatus of

the sheet transporting belt 20. Alternatively, the belt driving apparatus similar to those of the embodiment 1 may be applied to both apparatus.

[0062]

O Embodiment 3

Any of the above-descried embodiments 1 and 2 represent the belt driving apparatus applicable to the image forming apparatus. In contrast, this embodiment shows a typical mode of belt driving apparatus for widely driving a member to be driven.

A belt driving apparatus 100 related to Fig. 9(a) to Fig. 9(d) is equipped with a single flat belt 105 and tension members on which this flat belt 105 is worn. As this tension member, a drive pulley 151, two driven pulleys 152, 153, and also a tension pulley 154 are provided, to which driving force derived from a drive motor (not shown) is transferred. These driven pulleys 152 and 153 are positioned adjacent to this drive pulley 151, and are coupled to the member to be driven (not shown). The tension pulley 154 is employed so as to circulate the flat belt 105.

[0063]

Similar to the above-described embodiment 1, in this embodiment 3, plural columns (three columns in this example) of through holes 130 are formed in the flat belt 105 along a travel direction thereof. Also, plural columns of projections

140 are formed on either all or a portion of these pulleys 151 to 154 (in this example, the projections 140 are formed on the drive pulley 151, the driven pulleys 152 and 153). These projections 140 are located in correspondence with the through holes 130 of the flat belt 105. Since the projection 140 of the pulley 110 are engaged to the through holes 130 of the flat belt 105, the stable driving operation of the flat belt 105 is realized.

In accordance with this embodiment 3, similar to the embodiment 1, even in such a case that heavy loads are given to the driven pulleys 152 and 153 to which the member to be driven is coupled, and also the flat belt 105 tries to meander, the driving force can be firmly transferred to the member to be driven, while the operation force given to the hole portions of the through hole 130 of the flat belt 105 is distributed.

[0064]

Also, the belt driving apparatus 100 related to Fig. 9(b) is constructed of 3-column through hole type in such a manner that plural columns of through holes 131 are arrayed in an oblique manner along a belt meander direction (namely, width direction located perpendicular to travel direction), while these plural through holes 131 are not overlapped with each other. Furthermore, projections 141 corresponding to the above-explained through holes 131 are provided on either all, or a portion of pulleys 151 to 154. As a result, this belt

driving apparatus 100 can strength rigidity with respect to the belt width direction, as compared with the rigidity of the belt driving apparatus shown in Fig. 9(a).

Further, the belt driving apparatus 100 related to Fig. 9(c) is constructed of 2-column through hole type in such a manner that plural columns of through holes 132 are arrayed in an oblique manner along a belt meander direction (namely, width direction located perpendicular to travel direction), while these plural through holes 132 are not overlapped with each other. Furthermore, projections 142 corresponding to the above-explained through holes 132 are provided on either all, or a portion of pulleys 151 to 154.

[0065]

Moreover, the belt driving apparatus 100 related to Fig. 9(d) is constructed of 2-column through hole type in such a manner that plural columns of through holes 133 are arrayed in a parallel manner along a belt meander direction (namely, width direction located perpendicular to travel direction). Furthermore, projections 143 corresponding to the above-explained through holes 133 are provided on either all, or a portion of pulleys 151 to 154.

This mode of the belt driving apparatus 100 shown in Fig. 9(d) is not suitably operated in such a case that a large belt meandering operation occurs. However, when a load is given to both the driven pulleys 152 and 153, the two columns of

through holes 133 are engaged with the projections at the same time to drive the belt 105. As a consequence, when a heavy load is driven by the belt 105, the array of these through holes and projections of this belt driving apparatus 100 may achieve advantages.

Therefore, several modes of these belt driving apparatus according to this embodiment are combined with each other in accordance with a drive specification to be applied, and whereby the belt can be driven under stable condition, and further, higher rotation fluctuation preventing precision can be achieved.

[0066]

O Embodiment 4

Fig. 10 shows a belt driving apparatus which is applied to a copying machine (image forming apparatus) 80 of an embodiment 4 to which the present invention is applied.

In this drawing, a basic arrangement of the copying machine 80 is substantially similar to that of the embodiment 1, and is equipped with four photosensitive drums 11 (reference numerals 11K to 11C), two first intermediate transfer drums 31a and 31b, and a second intermediate transfer drum 32. However, an construction of a belt driving apparatus 160 employed in this embodiment 7 is different from that of the embodiment 1. Incidentally, the same, or similar reference numerals shown in the embodiment 1 will be employed as those for denoting

the same, or similar structural elements of this embodiment 7, and therefore, detailed explanations thereof are omitted.

In this embodiment, as shown in Fig. 10 to Fig. 12, the belt driving apparatus 160 drives respective photosensitive drums 11 (11K to 11C), first intermediate transfer drums 31a, 31b, and a second intermediate transfer drum 32. This belt driving apparatus 160 is provided with two flat belts 171, 172, and various sorts of tension members on which these flat belts 171 and 172 are tensioned or worn.

In this case, as the above-described tension member, there are driven (driven) pulleys 181 to 187, and tension pulleys 191 and 192 for circulating the respective flat belts 171 and 172. The driven pulleys 181 to 187 are mounted on one ends of the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a and 31b, and the second intermediate transfer drum 32 along axial directions thereof, respectively.

Incidentally, in this embodiment, the driven pulley 187 mounted on the second intermediate transfer drum 32 has a two-stage belt hanging plane over which the first flat belt 171 and the second flat belt 172 are hung.

[0067]

Then, the first flat belt 171 is hung over the tension pulley 191, the driven pulleys 181 to 184 which are mounted on the axes of the respective photosensitive drums 11 (11K

to 11C), and the driven pulley 117 which is mounted on the axis of the second intermediate transfer drum 32.

On the other hand, the second flat belt 172 is hung over the tension pulley 192, the driven pulleys 185 and 186 which are mounted on the axes of the first intermediate drums 31a and 31b, and the driven pulley 187 which is mounted on the axis of the second intermediate transfer drum 32.

Incidentally, pulley shafts (not shown) provided with the pulleys 181 to 187, 191, and 192, respectively, are supported by respective slide bearings which are provided on side surfaces of the copying machine 80, and therefore, these pulley shafts can be freely rotated. Also, in this example, among the two-stage belt hanging planes of the driven pulley 187, the diameter of the belt hanging plane provided for the first flat belt 171 is formed larger than the diameter of the belt hanging plane provided for the second flat belt 172.

More specifically, in accordance to this embodiment, while the flat belts 171 and 172 are equipped with, for instance, one column of through holes 175 along travel directions of these flat belts 171 and 172, respectively, projections 176 corresponding to the above-described through holes 175 are provided on either all of a portion of the pulleys over which these flat belts 171 and 172 are hung. These flat belts are constituted by such a perforation belt capable of transferring driving force by fitting these projections 176 to the through

holes 175.

[0068]

In this case, as to a way how to apply power derived from a driving motor (drive source not shown) to which shaft, it is preferable that the driving force derived from the driving motor is entered to a pulley shaft, whose winding angles between flat belts and pulleys are large.

In this embodiment, for instance, the driving force derived from the driving motor may be entered to the shaft of the second intermediate transfer drum 32. Alternatively, the driving force derived from the driving motor may be entered into another pulley shaft.

Also, with respect to materials of these flat belts and materials of these pulleys, any materials may be properly selected in a similar manner to that of the embodiment 1. For example, as these flat belts, metal materials such as stainless steel, nickel, and titanium are preferably used in view of durability and processing precision etc. On the other hand, as materials of these pulleys, metal materials such as stainless steel, aluminum, and carbon steel are preferably used in view of durability and processing precision etc.

[0069]

In particular, in this embodiment, free rotating members 200 (concretely speaking, reference numerals 200a and 200b) are mounted on the driven pulleys 185 and 186 of the first

intermediate transfer drums 31a and 31b. The free rotating members 200 are freely rotatable and are positioned in a coaxial manner to shafts of these driven pulleys 185 and 186. The flat belt 171 is worn via the free rotating member 200a over the driven pulleys 181 and 182 of the photosensitive drums 11 (11K, 11Y). On the other hand, the flat belt 171 is worn via the free rotating member 200b over the driven pulleys 183 and 184 of the photosensitive drums 11 (11M, 11C).

In this case, as the free rotating members 200, various sorts of members may be freely selected, for instance, a collar is selectable if these selected members are freely rotatable with respect to the shafts of the driven pulleys. In this example, for example, as illustrated in Fig. 13(a)(b), a ball bearing is employed. This ball bearing is constituted by an inner ring case 201 and an outer ring case 202. The inner ring case 201 is inserted under pressure and coupled to the shafts of the above-explained driven pulleys 185 and 186. The outer ring case 202 is rotatably provided via a ball 203 on the outer side of the inner ring case 201.

[0070]

Also, the free rotating members 200 may preferably restrict the positions of the first intermediate transfer drums 31a and 31b with respect to the axial direction of the rotary shaft 310.

When the above-described free rotating members 200 has

the degree of freedom along the axial direction, this may cause the meandering operations of the flat belts 171 and 172 to occur. For example, in a case that a flat belt equipped with holes such as a perforation belt is used, either the projections 176 formed on the driven pulleys 181 and 182 provided for the photosensitive drums 11 (namely, drums 11K and 11Y in this example) or the projections 176 formed on the driven pulleys 183 and 184 provided for the photosensitive drums 11 (namely, drums 11M and 11C in this example) are rubbed with the through holes 175 formed in the flat belts 171 and 172, so that the hole portions of the through holes 175 is easy to destroy. The driven pulleys 181 and 182 are located on the upper stream side of the free rotating members 200, whereas the driven pulleys 183 and 184 are located on the lower stream side thereof.

In this case, as the axial direction restriction of the free rotating member 200, as shown in Fig. 13(b), for example, a position restricting member 210 such as an E-ring and an O-ring may be provided on both sides, or one side of this free rotating member 200. In this example, the position restricting members 210 are provided on both sides of the free rotating member 200.

[0071]

Also, in this embodiment, the flat belts 171 and 172 are worn over the peripheral planes of the free rotating members 200. As indicated by a virtual line of Fig. 13(b), it is

preferable that while projections 205 are provided on the peripheral planes of the free rotating member 200 (in this case, peripheral plane of outer ring case 202) in correspondence with the through holes 175 of the flat belts 171 and 172, the positional restriction is carried out with respect to the axial directions between the free rotating member 200 and the flat belts 171 and 172.

[0072]

Next, a description will be given on operations of the belt driving apparatus of the image forming apparatus according to this embodiment.

In this embodiment, when driving force derived from a drive motor is entered to the rotation shaft of the second intermediate transfer drum 32, the driven pulley 187 of this second intermediate transfer drum 32 is rotated, so that the driving force is transferred via the second flat belt 172, the driven pulleys 185 and 186, and the tension pulley 192 to the first intermediate transfer drums 31a and 31b.

On the other hand, when the driven pulley 187 of the second intermediate transfer drum 32 is rotated, the driving force is transferred via the first flat belt 171, the driven pulleys 181 to 184, the tension pulley 192, and the free rotating members 200 (namely, members 200a and 200b) to the respective photosensitive drums 11 (namely, drums 11K to 11C).

[0073]

At this time, the first flat belt 171 is worn via the free rotating member 200a, the tension pulley 191, and the rotating member 200b over the driven pulleys 181 to 184, which are located adjacent to the respective photosensitive drums 11 at a winding angle larger than or equal to approximately 180 degrees.

Under this condition, since the winding regions between the first flat belt 171 and the respective driven pulleys 181 to 184 are increased, not only transferring the driving force applied to the driven pulleys 181 to 184 is stable, but also since the force exerted to the hole portions of the through holes 175 is distributed, which is caused by fitting the through holes 175 of the first flat belt 171 to the projections 176 of the driven pulleys 181 to 184, the destruction of the hole portions of the through holes 175, which is caused by that local stress is applied to the hole portions of the through holes 175, can be advantageously avoided.

[0074]

Particularly, in this example, although the rotation shaft direction of the first intermediate transfer drums 31a and 31b is reversed with respect to the rotation direction of the free rotating member 200, since the free rotating member 200 can be freely rotated with respect to the rotation shafts of the first intermediate transfer drums 31a and 31b, movement of the first flat belt 171 is not deteriorated.

Assuming now that the free rotating member 200 is not employed, the first flat belt 171 is directly worn on the rotation shafts of the first intermediate transfer drums 31a and 31b. However, in this assumption case, both a load and a driving load given to the flat belt 171 are increased and the damage of the first flat belt 171 caused by this friction would be increased, thus to be undesirable.

[0075]

In addition, since the free rotating members 200 use the rotation shafts of the first intermediate transfer drums 31a and 31b as the supporting members, the exclusively-used tension pulley supporting member is not required. Also, the installation space of the free rotating members 200 is not unnecessarily enlarged.

[0076]

The belt driving apparatus 160 according to the embodiment is not limited only to the above-explained structures, but also this design of the belt driving apparatus 160 may be changed as shown in, for example, Fig. 14.

The belt driving apparatus 160 shown in Fig. 14 utilizes a mode with employment of a speed reduction mechanism.

In this drawing, the speed reduction mechanism is that driving force derived from a drive motor (not shown) is entered into a shaft 220 by which a drive pulley 221 is rotatably supported, a rotation speed is reduced by way of a belt transmission,

and the driving force is transferred to an output axis.

In this case, a rotation shaft of a driven pulley 231 and a rotation shaft of a driven pulley 232 are common. A first flat belt 241 is worn over a drive pulley 221 which accepts input power supplied from the drive motor and is worn over the driven pulley 231. On the other hand, a second flat belt 242 is worn between the driven pulley 232 and another driven pulley 251 provided at an output shaft 250.

[0077]

In such a reduction mechanism, in a case that a heavy load is given to the output shaft 250, a belt tensile load given to the first flat belt 241 is different from a belt tensile load given to the second flat belt 242. The second flat belt 242 receives larger tensile load force. As a result, there is a risk that such a winding angle which is sufficient in the first flat belt 241 in view of slips may be insufficient in the second flat belt 242.

Under such a circumstance, in a case that the winding angle of the second flat belt 242 which is worn around the driven pulley 251 is increased, as shown in Fig. 14, the rotation shaft (input shaft) 220 of the driving pulley 221 is provided with the free rotating member 200, which is freely rotatable and is positioned in a coaxial manner to this rotation angle 220. The second flat belt 242 is wounded with respect to this free rotating member 200, and whereby the winding angles of

the second flat belt 242 with respect to the driven pulley 232 and the driven pulley 251 increases, while such an extra tension pulley supporting member is not provided and also the space is not required.

[0078]

Incidentally, as apparently from the foregoing descriptions, the belt driving apparatus 160 (namely, mode using free rotating members 200) of this embodiment may be applied to the belt driving apparatus of the image forming apparatus according to the embodiment 2.

[0106]

[Example]

O EXAMPLE 1

While the image forming apparatus according to the embodiment 1 is employed as an experiment model, the Inventors of the present invention actually investigated concentration fluctuations in output images and positional shifts in images. As a result of their experiments, even under such a condition that driven pulley shaft torque was given by which a flat belt having no hole was could not be driven, this image forming apparatus could succeed to reduce both the concentration fluctuations in the output images and the positional shifts of the images lower than, or equal to recognizable limit values.

One example of the above-described examples is shown in Fig. 15.

In this drawing, while a variation in engagements between through hole portions of a belt and projections of a pulley could be reduced up to $\Delta V0 - p < 0.3\%$ which is a target level, a fluctuation in image concentration could be reduced lower than, or equal to the recognizable limit value.

[0080]

Also, in accordance with this example, an adverse influence caused by belt meanders which were produced by increasing belt initial tension could be reduced.

One example is shown in Fig. 16. Incidentally, a result of comparative examples (belt though hole is one-column hole) is shown in Fig. 17.

First, considering the comparative example, Fig. 17 shows progress in rotation fluctuation levels when a belt is continuously driven as follows: That is, 1) belt tension is increased from "T_0" to "T_1" without applying a load to a driven pulley (see region "C1"). 2) Next, the belt tension is returned to "T_0", only a load equal to a half of a target value is applied to the driven pulley, and the belt tension is increased from "T_0" to "T_1" in a similar manner to the previous case (see region "C2"). 3) Furthermore, the belt tension is returned to "T_0", a load equal to the target value is applied to the driven pulley, and the belt tension is increased from "T_0" to "T_1" (see region "C3").

[0081]

As apparent from this drawing, when the belt tension is changed from the item 1) to the item 2), it can be seen that although the belt tension is returned to the initial condition, the level of the rotation fluctuation is not returned to the initial condition. This reason is given as follows. This is not an adverse influence due to the load because the item 1) is no load drive, but an adverse influence cased by that the belt meandering operation occurs, which gives the damage to the hole portions of the through holes when the belt tension is increased up to "T_1".

Also, in the items 2) and 3) where the load is given to the driven pulley, it can be seen that the rotation fluctuation level is gradually deteriorated, and therefore, the adverse influence caused by the load is mixed with the adverse influence caused by the belt meandering operation.

After the experiment has been accomplished, when the hole portions of the belt through holes are observed, the damage produced by engaging the hole portions of the belt through-holes cause the hole portions to be plastic-deformed, and cracks are produced in a certain hole portion. If such a phenomenon occurs, then it is practically difficult to play a role as apparently an image forming apparatus, and further, a driving force transmission apparatus.

[0082]

To the contrary, Fig. 16 shows progress in rotation

fluctuation levels when the belt is continuously driven as follows, into which this example has been conducted: That is, 1) while belt tension is set to "T_0", a load given to a driven pulley is gradually increased from 0 to the target value (see region "A1"). 2) Next, the belt tension is returned to "T_0", the belt tension is set to T_1 ($T_0 \times 1.4$), and a load given to the driven pulley is gradually increased from 0 to the target value (see region "A2"). 3) Furthermore, after the belt tension is returned to "T_0", the belt tension is set to T_2 ($T_0 \times 1.7$), and the load given to the driven pulley is gradually increased from 0 to the target value (see region A3).

As apparent from this drawing, when the load given to the driven pulley is increased, there is such a trend that the rotation fluctuation is slightly deteriorated. However, the level of this deteriorated rotation fluctuation is small. Also, there is substantially no adverse influence caused by the belt meandering operation which is produced by increasing the belt tension. In other words, while the experiment is carried out, in a case that the belt tension is returned to the initial condition so as to set no load condition, the level of the rotation fluctuations is also returned to the initial condition, resulting in reproducibility.

Conversely, since the belt tension is increased, the gripping force exerted between the pulley and the flat belt is increased, and the rotation fluctuation caused by the

engagement between the pulley and the flat belt may be reduced.

As a consequence, since this example 1 is conducted, "ΔV0 - p" corresponding to the concentration fluctuation recognizable limit value of the output image could be reduced smaller than, or equal to 0.3% and a driving force transmission system having higher reliability with respect to the load and the belt meandering operation could be provided.

[0083]

O Example 2

The image forming apparatus according to the embodiment 4 is employed as an experiment mode and the Inventors of the present invention actually investigated concentration fluctuations in output images and positional shifts in images. In accordance with the experiment performed by the Inventors, even when a mode uses a flat belt having no hole, since a winding angle of the flat belt with respect to a pulley can be sufficiently increased, a slip occurred between the flat belt and the pulley can be effectively avoided.

Even under such a condition that driven pulley shaft torque was given by which a flat belt having no hole was slipped and could not be driven, this image forming apparatus could succeed to reduce the concentration fluctuations in the output images and the positional shifts of the images lower than, or equal to recognizable limit values.

One example is shown in Fig. 18.

In this drawing, while a variation in engagements between through hole portions of a belt and projections of a pulley could be reduced up to $\Delta V0 - p < 0.3\%$ which is a target level, a fluctuation in image concentration could be reduced lower than, or equal to the recognizable limit value.

[0084]

[Effect of the Invention]

As previously described in detail, in accordance with the driving force transmission apparatus of the invention, the following effects can be achieved. That is, in the system for transferring the driving force by wearing an endless-shaped flat belt over a plurality of tension members, the plurality of columns of the through holes which are arrayed in the flat belt along the travel direction thereof, and also the projections are formed on at least one of the plural tension members over which the flat belt is worn. While the engaging conditions between the through holes and the projections can be firmly maintained, the driving force transmission apparatus owns such a structure capable of avoiding concentration of the operation force onto the hole portions of the through holes. As a consequence, apparently, this driving force transmission apparatus can effectively prevent the slips occurred between the flat belt and the tension members, and also, can effectively distribute the force exerted to the hole portions of the through holes under such a condition that the heavy rotation load is

applied to the driven member which is coupled to any one of the tension members. While the destruction of the hole portions of the through holes is effectively prevented, the driving force transmission apparatus can transfer the driving force to the driven member under stable condition.

As a consequence, in the image forming apparatus with employment of such a driving force transmission apparatus, since the destruction of the hole portions of the through holes formed in the flat belt having the through holes can be effectively suppressed, and also, the driving force can be stably transferred to the image carrier corresponding to the member to be driven, this image forming apparatus can produce the output image without any image defect, while the lifetime of this flat belt having the through holes can be extended.

[0085]

Also, in accordance with the driving force transmission apparatus of the present invention, the following effects can be achieved. That is, in the system for transferring the driving force by wearing the endless-shaped flat belt over a plurality of tension members, while the free rotating member which can be freely rotated is provided in the coaxial manner with respect to the rotation shaft of at least one tension member among the plural tension members to which the driving force is transferred, the flat belt is worn via the free rotating member with respect to the adjoining tension members which are different

from such a tension member where this free rotating member is provided. As a consequence, for example, the winding angle of the flat belt with respect to the adjoining tension members can be set to the large angle. Moreover, the specific space is no longer required to be formed as the setting space of this free rotating member.

As a result, in such an embodiment that, for instance, the member to be driven is coupled to at least one of these adjoining tension members, even under such a condition that the heavy rotation load is applied to the member to be driven, the setting space for the auxiliary tension member supporting member used to wear the flat belt is not specifically required, and the driving force can be stably transferred to the member to be driven without unnecessarily extending the layout space.

Moreover, in the image forming apparatus with employment of such a driving force transmission apparatus, the auxiliary tension member supporting member is not specifically required so as to wear the flat belt. In addition, since the driving force can be transferred under stable condition to the image carrier corresponding to the member to be driven, this image forming apparatus can produce such an output image having no image defect, while avoiding such a problem that this image forming apparatus is made bulky.

[Brief Description of the Drawings]

Fig. 1(a) is an explanatory diagram for showing an outline

of a driving force transmission apparatus according to the present invention and Fig. 1(b) is an explanatory diagram for showing an outline of a driving force transmission apparatus according to another embodiment of the invention.

Fig. 2 is an explanatory diagram for showing an entire structure of an image forming apparatus according to an embodiment 1.

Fig. 3 is a perspective explanatory diagram for showing a driving force transmission apparatus employed in the embodiment 1 in detail.

Fig. 4(a) is an explanatory diagram for showing a front view of the driving force transmission apparatus employed in the embodiment 1, and Fig. 4(b) is an explanatory diagram for showing a plan view thereof.

Fig. 5(a) is an explanatory diagram for showing a major portion of the driving force transmission apparatus employed in the embodiment 1, Fig. 5(b) is a diagram viewed from a direction "B" of Fig 5(a), and Fig. 5(c) is a diagram viewed from a direction "C" of Fig. 5(a).

Fig. 6(a) is an explanatory diagram for showing an engagement state between through holes of flat belts and projections of pulleys in a comparison mode, Fig. 6(b) is an explanatory diagram for showing an engagement state between through holes of flat belts and projections of pulleys in this embodiment, Fig. 6(c) is an explanatory diagram for showing

an engagement state between through holes of flat belts and projections of through holes in a modified mode of this embodiment when the flat belt is meandered; and Fig. 6(d) is an explanatory diagram for showing an engagement state between through holes of flat belts and projections of through holes in this embodiment when the flat belt is meandered.

Fig. 7 is an explanatory diagram for showing a modified mode of the driving force transmission apparatus employed in the embodiment 1.

Fig. 8 is an explanatory diagram for showing an overall structure of an image forming apparatus according to an embodiment 2.

Fig. 9(a) to Fig. 9(b) are explanatory diagrams for showing both a driving force transmission apparatus and modified embodiments thereof, according to an embodiment 3.

Fig. 10 is an explanatory diagram for showing a major portion of an image forming apparatus according to an embodiment 4.

Fig. 11 is a perspective explanatory diagram for showing an outline of a driving force transmission apparatus employed in the embodiment 4.

Fig. 12 is a perspective explanatory diagram for showing the driving force transmission apparatus employed in the embodiment 4, as viewed from a rear surface side of Fig. 11.

Fig. 13(a) is an explanatory diagram for showing a concrete

example of a free rotating member, and Fig. 13(b) is an explanatory diagram for showing an example of position restrictions with respect to an axial direction of the free rotating member.

Fig. 14 is an explanatory diagram for showing a modified mode of a driving force transmission apparatus employed in the embodiment 4.

Fig. 15 is an explanatory diagram for showing a rotation fluctuation in a driven pulley employed in a driving force transmission apparatus according to an example 1.

Fig. 16 is an explanatory diagram for showing a drive result of the driving force transmission apparatus according to the example 1.

Fig. 17 is an explanatory diagram for showing a drive result of a driving force transmission apparatus according to a comparative example.

Fig. 18 is an explanatory diagram for showing a rotation fluctuation in a driven pulley employed in a driving force transmission apparatus according to an example 2.

Fig. 19 is an explanatory diagram for showing problems of a driving force transmission apparatus according to a related art.

Fig. 20 is an explanatory diagram for showing a relationship between the concentration fluctuation allowable value and the rotation fluctuation of an image carrier member in the image forming apparatus using the driving force transmission apparatus

according to the related art.

Fig. 21 is an explanatory diagram for showing a relationship between the average rotation speed of the driven pulley and the load torque in the driving force transmission apparatus according to the related art, using the flat belt.

Fig. 22 is an explanatory diagram for showing one example of the driving force transmission apparatus according to the related art, using the flat belt.

Fig. 23(a) is an explanatory diagram for showing another example of the driving force transmission apparatus according to the related art, using the flat belt, and Fig. 23(b) is a diagram for showing this driving force transmission apparatus, as viewed from the direction B of Fig. 23(a).

Fig. 24is an explanatory diagram for showing a relationship between the driven shaft load and the rotation average speed of the driven pulley in the driving force transmission apparatus related to Fig. 23.

[Description of the Reference Numbers]

1 flat belt

2(2a-2d) tension members

3 through hole

4 projection

5 free rotating member

[Name of Document] Abstract

[Abstract]

[Purpose]

In a mode in which an endless-shaped flat belt is worn over a plurality of tension members, while a transmission error of driving force is eliminated caused by a slip between the flat belt and the tension members such as pulleys, the driving force is transferred under stable condition even under a condition that a heavy load is given to a member to be driven.

[Solving means]

While plural columns of through holes 3 are formed in at least one of flat belts 1 along a travel direction of the flat belts 1, plural columns of projections 4 are provided on at least one of tension members 2 along a rotation direction of the tension member 2. This flat belt 1 is worn over these tension members 2. The through holes 3 formed in the flat belt 1 are fitted to these projections 4. Also, a free rotating member 5 is mounted on at least one tension member 2a of the plural tension members 2 to which the driving force is transferred. This free rotating member 5 is freely rotatable and is positioned in a coaxial manner with respect to a rotation shaft of this tension member 2a. The flat belt 1 is worn via the free rotating member 5 over such tension members 2b and 2c, which are different from the tension member 2a on which this free rotating member 5 is mounted, and are located adjacent to each other. Further,

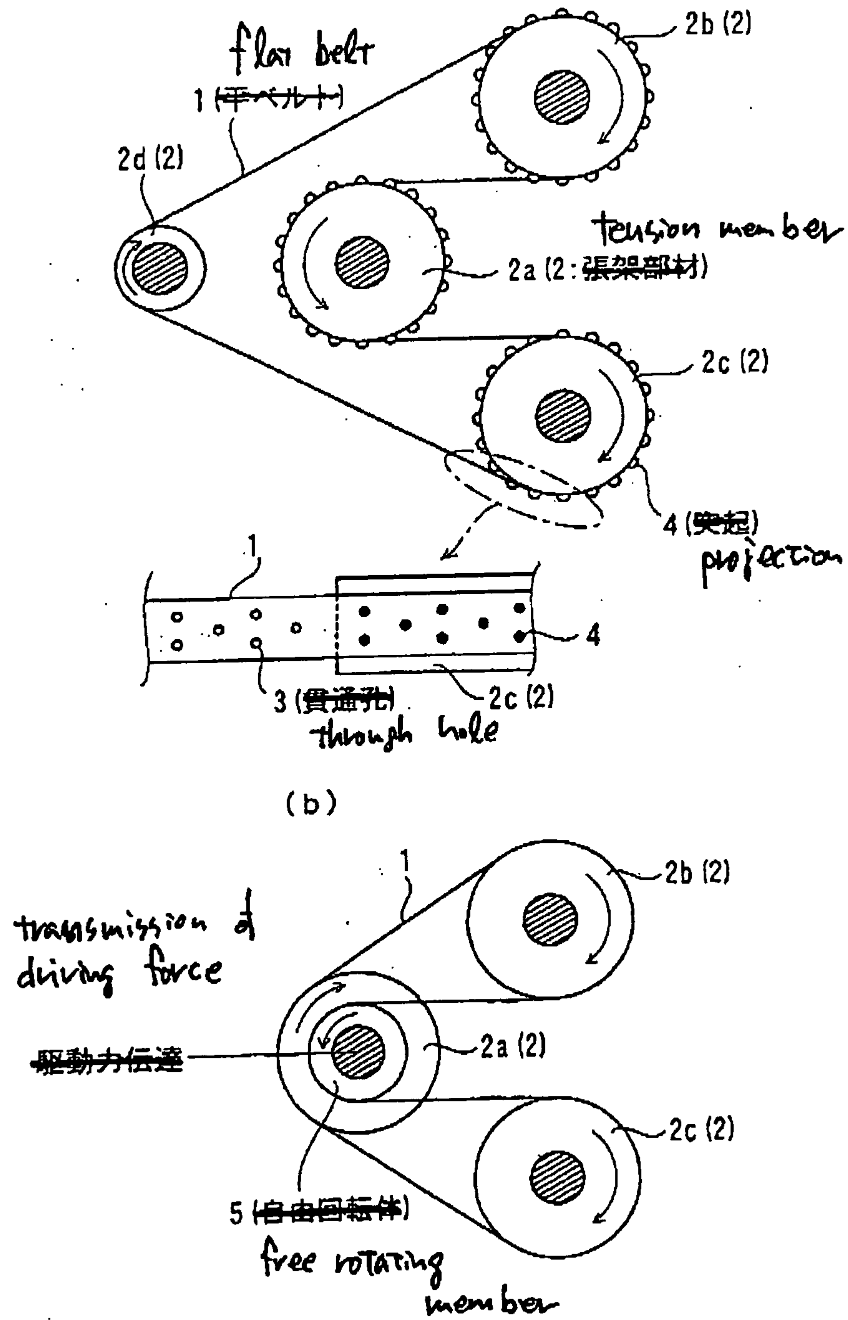
an image forming apparatus with employment of these driving force transmission apparatus may be realized.

[Selected Drawing] Figure 1

【~~書類名~~】 ~~図面~~ Drawings
Name of Document
【~~図１~~】

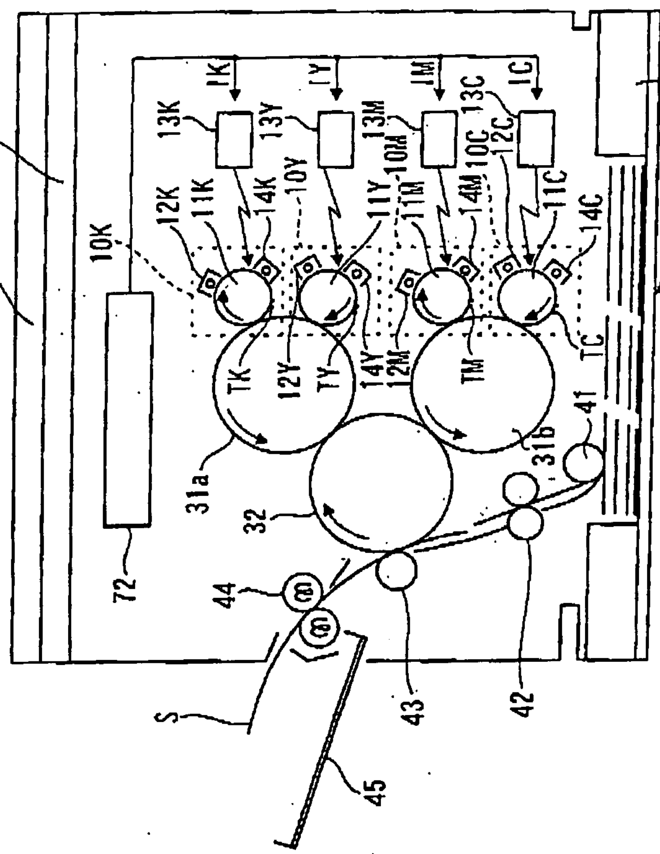
Fis. 1

(a)



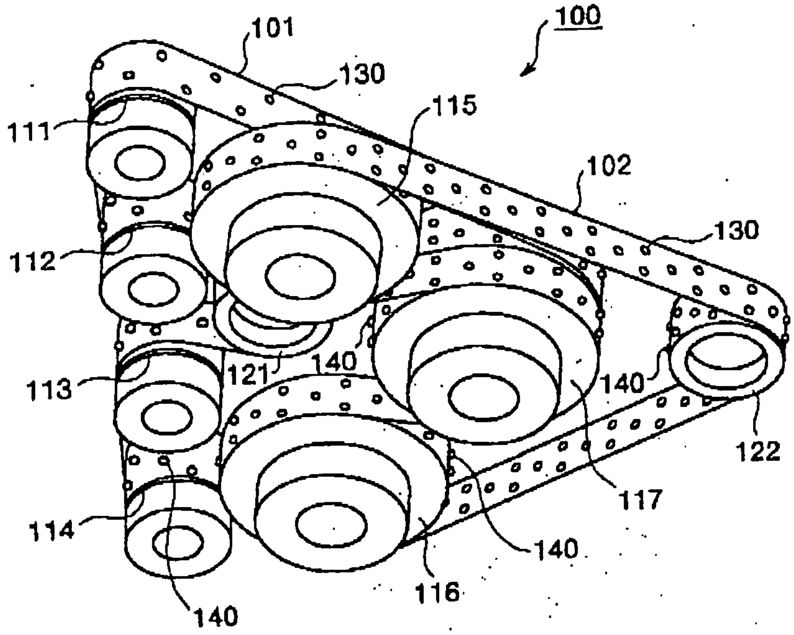
【~~図２~~】

Fig. 2


IK
IY
IM
IC
13K
13Y
13M
13C
40
71
10M
10C
12C
11K
14K
10Y
11Y
11M
14M
11C
12K
14C
10K
70
80
TK
12Y
TY
14Y
12M
TM
TC
41
31b
31a
32
72
44
43
42
S
45

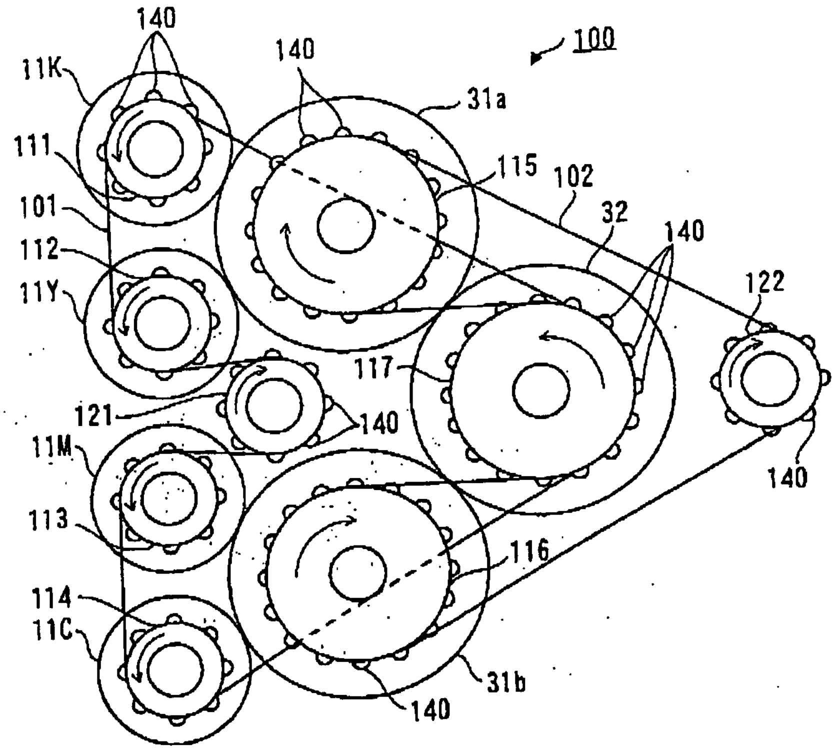
【~~図３~~】

Fig 3

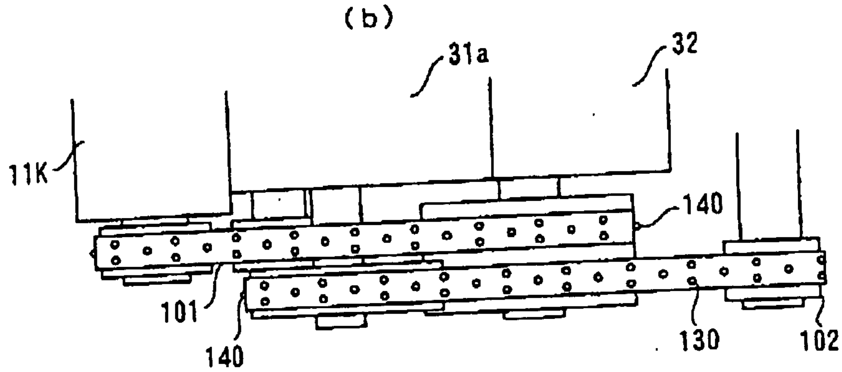

100
101
130
111
115
102
112
130
121
140
113
140
122
117
114
140
116
140

【~~図４~~】
Fig. 4

(a)

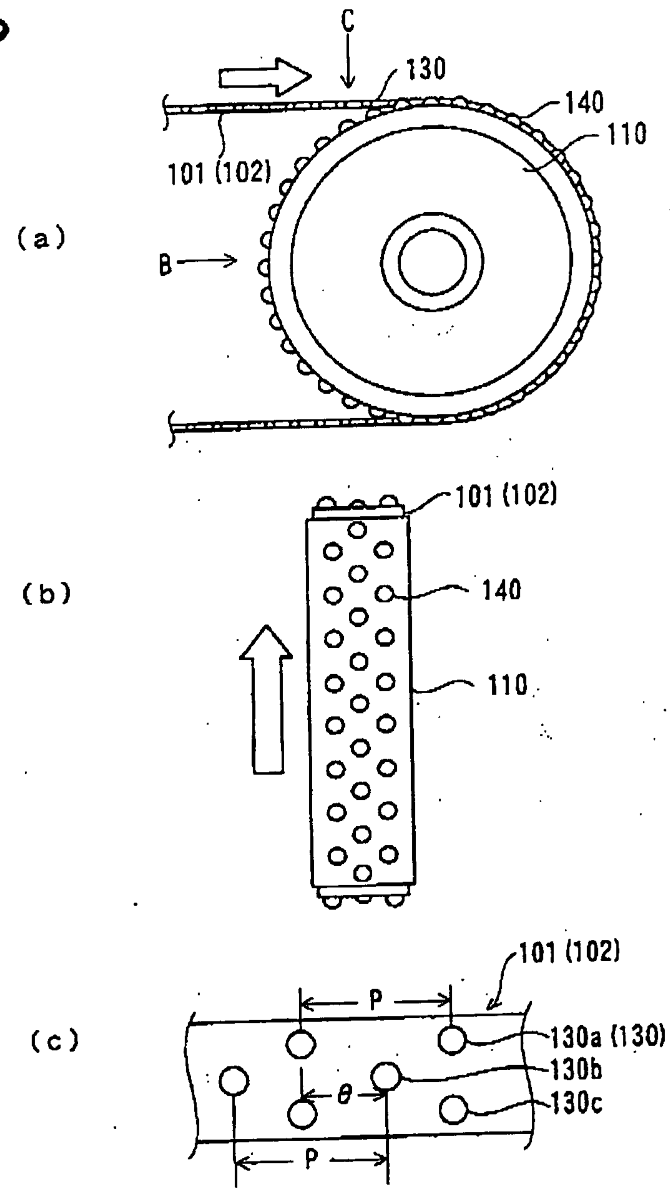

140
11K
140
100
31a
111
115
102
101
32
112
140
11Y
122
117
121
140
11M
140
113
116
114
11C
31b
140

(b)


31a
32
11K
140
101
130
102
140

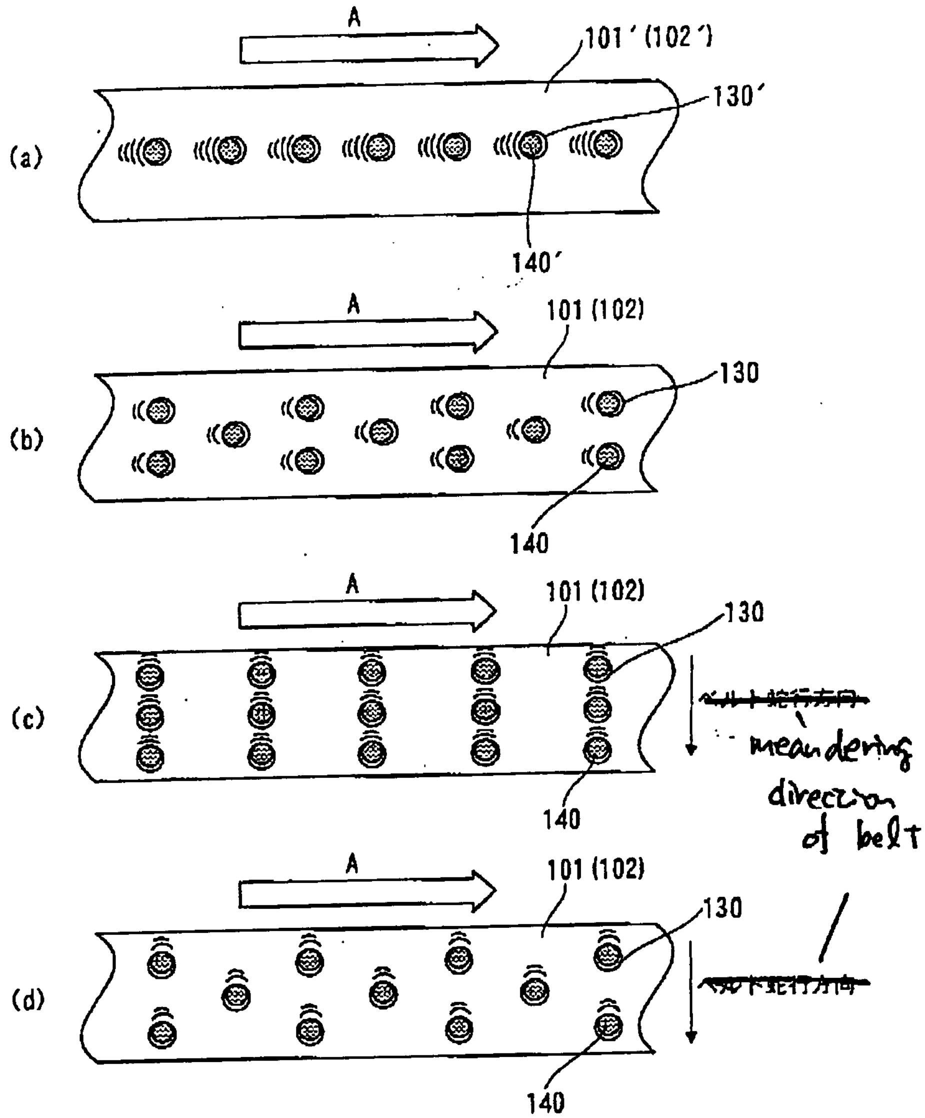
【~~図5~~】

Fig. 5


C
130
140
110
101 (102)
(a)
B
(b)
101 (102)
140
110
(c)
101 (102)
P
130a (130)
130b
θ
130c
P

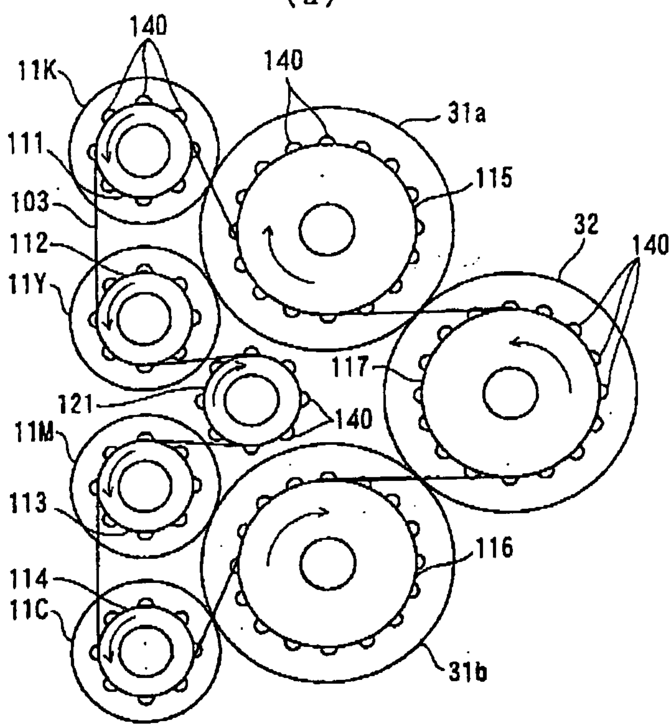
【~~図６~~】

Fig.6

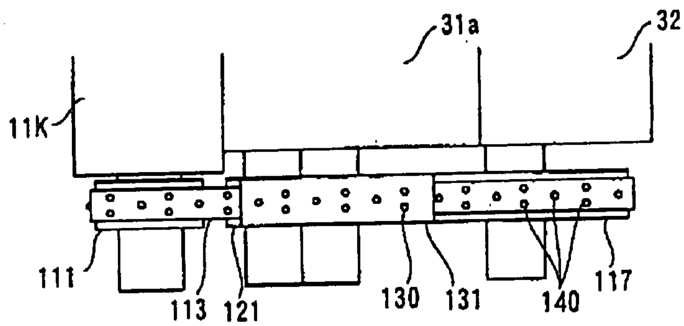

A
101′(102′)
130′
(a)
140′
A
101 (102)
130
(b)
140
A
101 (102)
130
(c)
~~ベルト蛇行方向~~
meandering direction of belt
140
A
101 (102)
130
(d)
~~ベルト蛇行方向~~
140

【~~図7~~】
Fig. 7

(a)

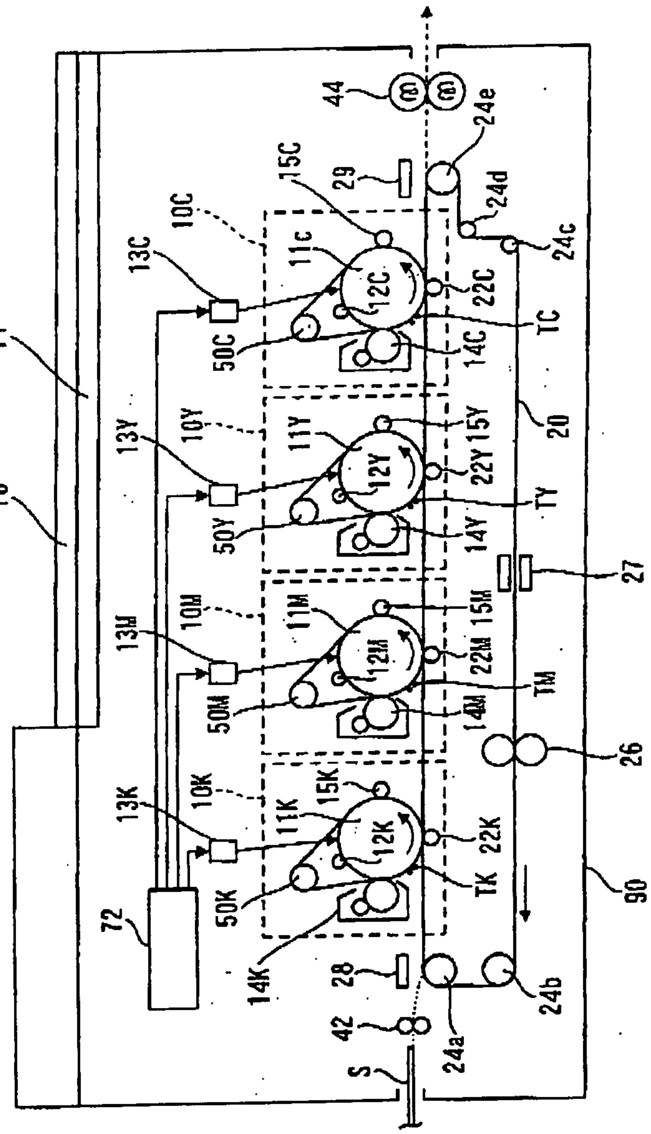

140
11K
140
31a
111
115
103
112
32
140
11Y
117
121
140
11M
113
116
114
11C
31b

(b)


31a
32
11K
111
113
121
130
131
140
117

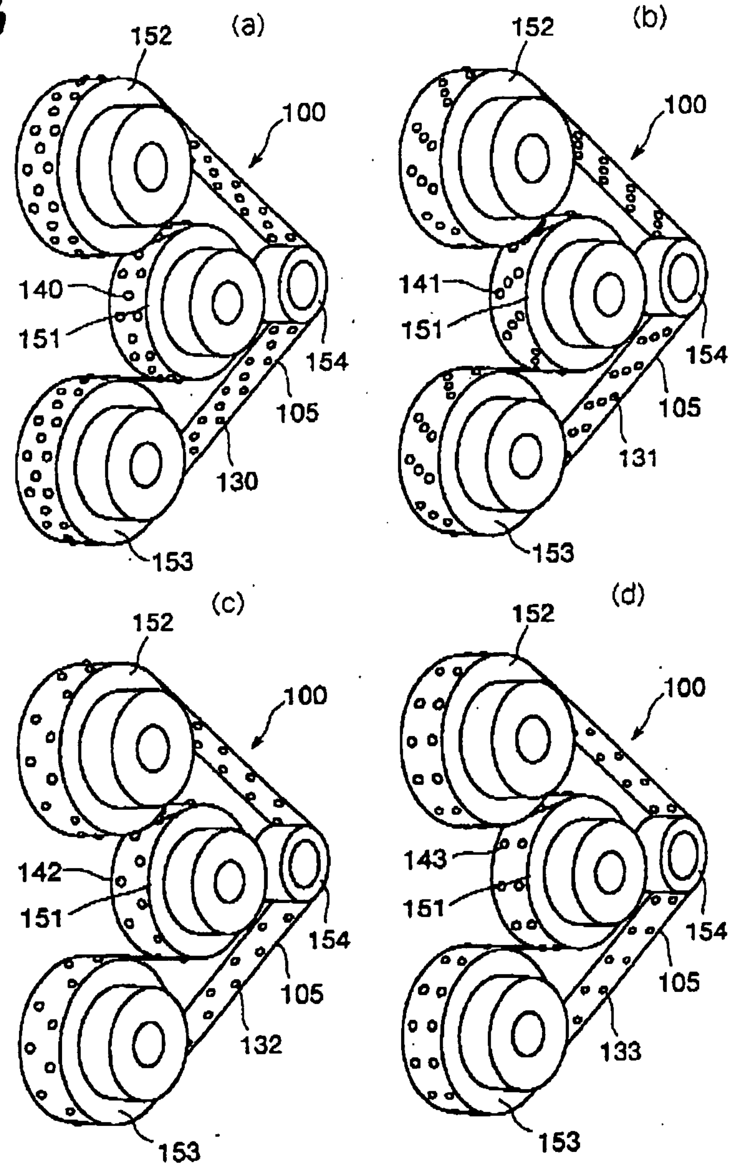
【~~図８~~】

Fig. 8


44
24e
29
15C
24d
10C
24c
13C
11c
12C
22C
TC
71
50C
14C
20
13Y
10Y
11Y
15Y
12Y
22Y
70
TY
50Y
14Y
27
13M
10M
11M
15M
12M
22M
TM
50M
14M
26
13K
10K
15K
11K
12K
22K
TK
90
72
50K
14K
28
24b
42
24a
S

~~【図9】~~

Fig. 9


(a)
152
100
140
151
154
105
130
153
(b)
152
100
141
151
154
105
131
153
(c)
152
100
142
151
154
105
132
153
(d)
152
100
143
151
154
105
133
153

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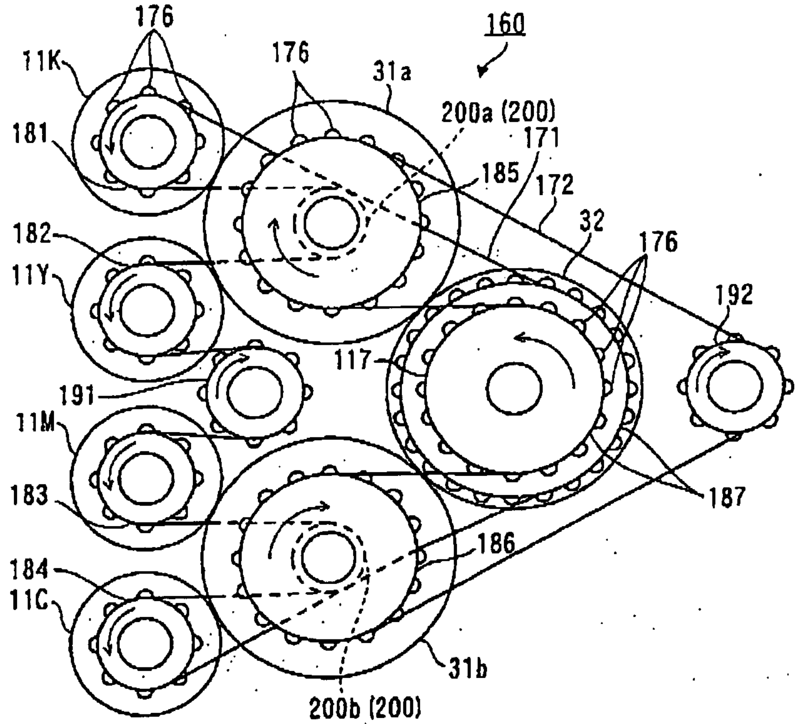
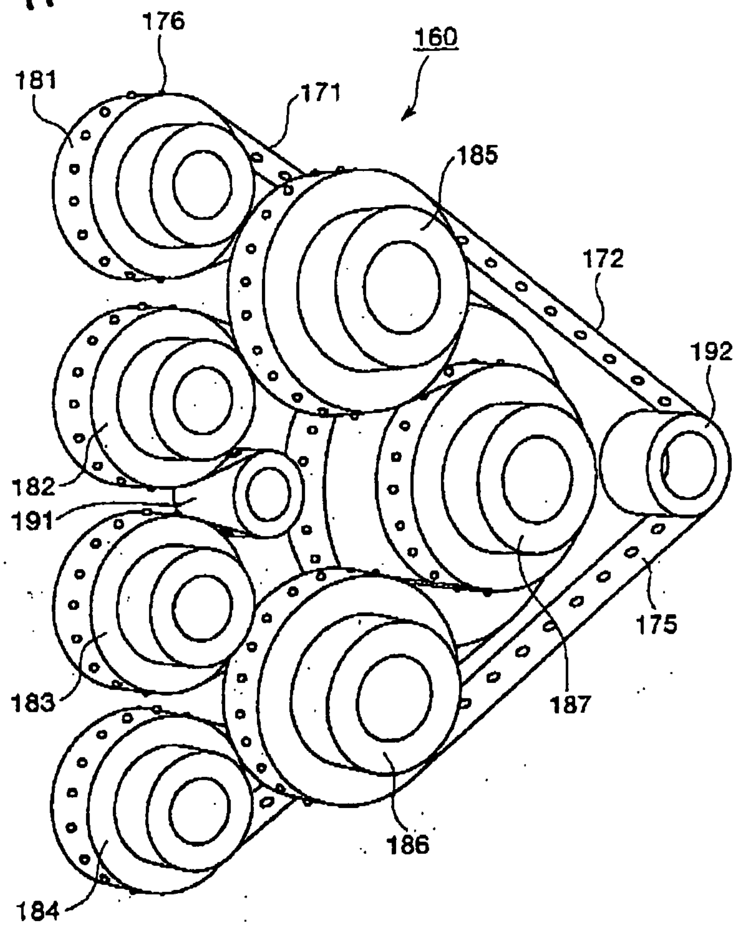
~~【図１０】~~

Fig. 10



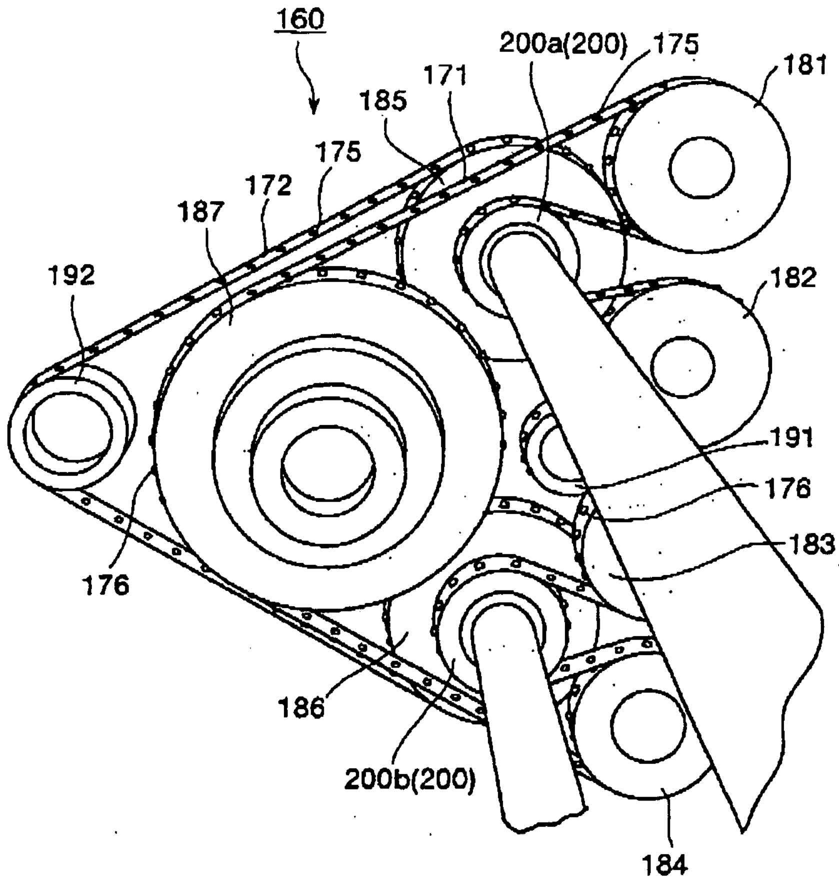
【~~図１１~~】

Fig. 11



【~~図１２~~】

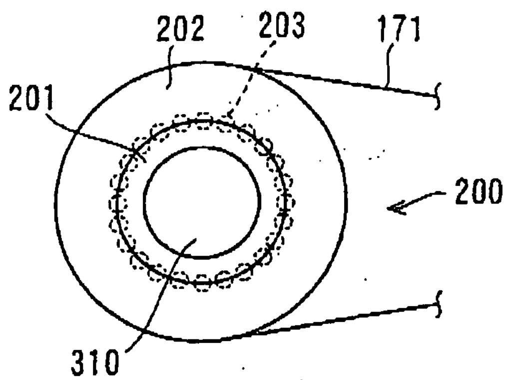
Fig. 12


160
200a(200)
175
181
185
171
175
172
187
192
182
191
176
183
176
186
200b(200)
184

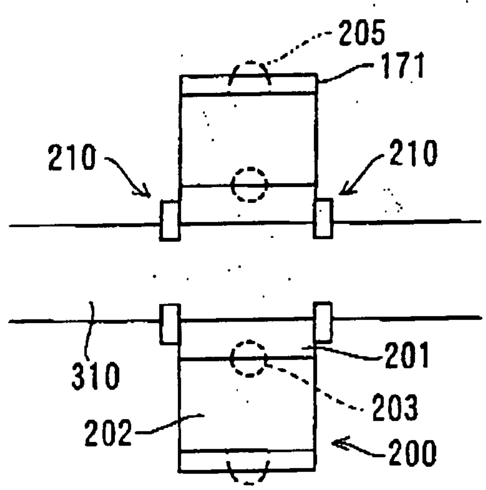
【~~図１３~~】

Fig. 13

(a)

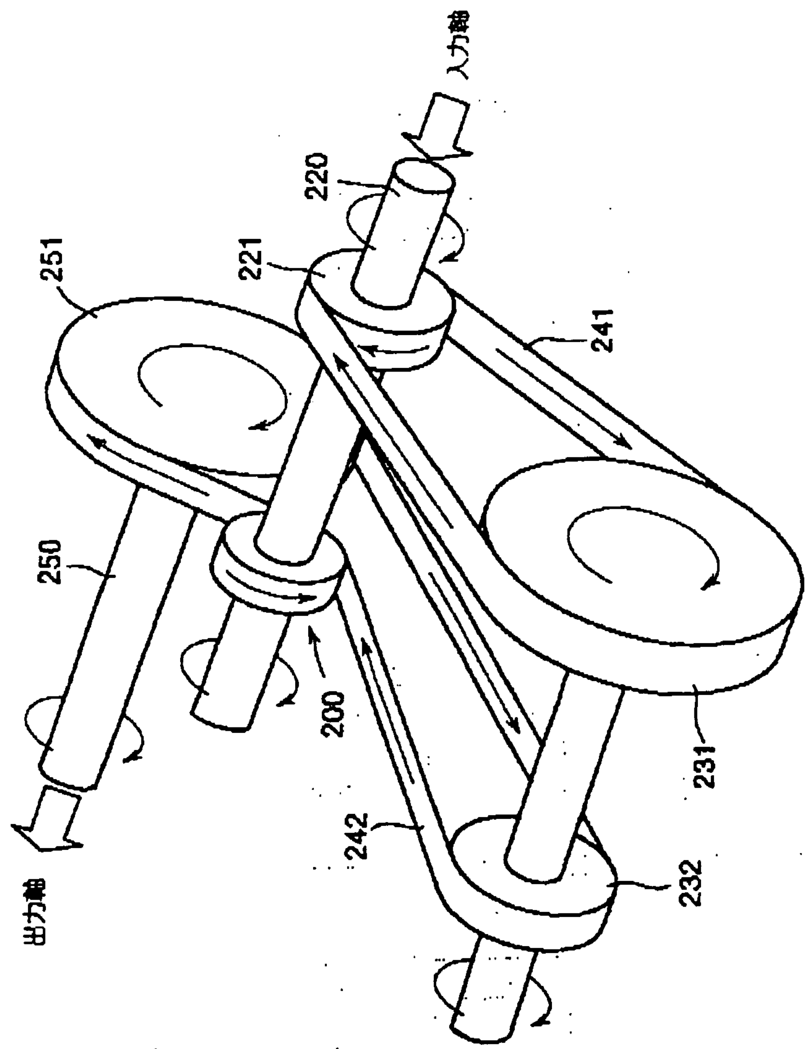


(b)



【~~図１４~~】

Fig. 14



[~~図27~~]

Fig. 15

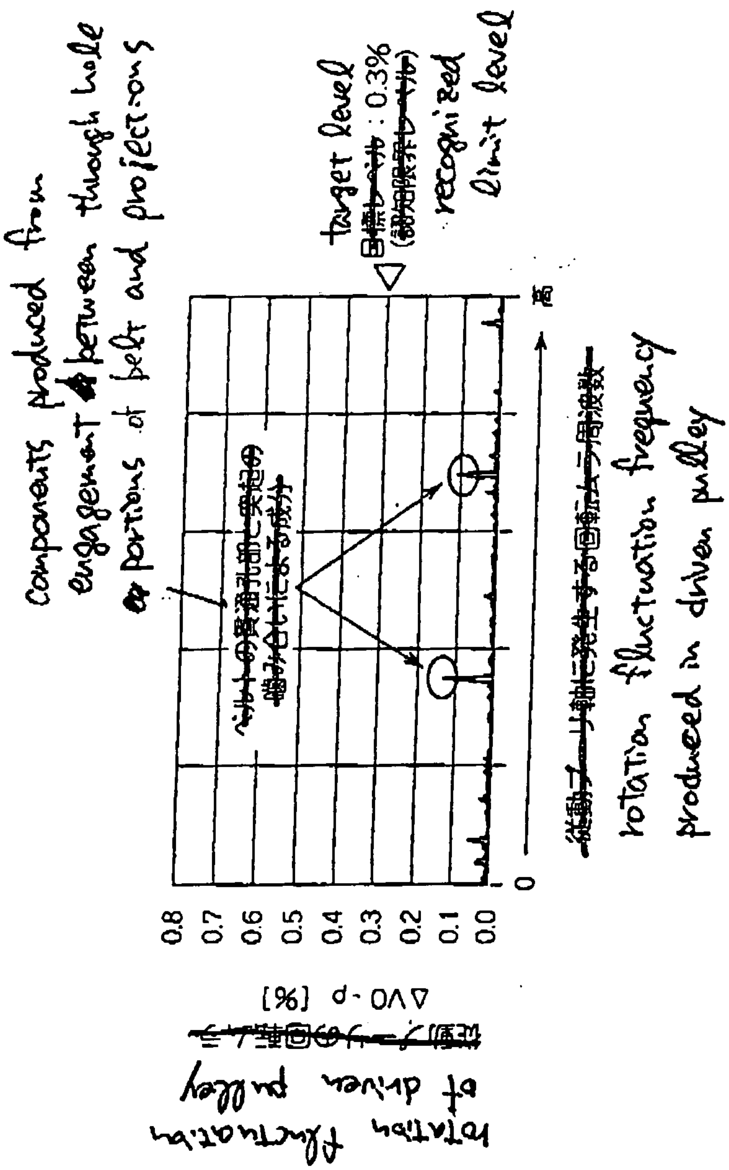

Components produced from engagement between through hole portions of belt and projections
target level : 0.3%
recognized limit level
rotation fluctuation frequency produced in driven pulley
0
高
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
ΔVO-p [%]
rotation fluctuation of driven pulley

FIG. 16

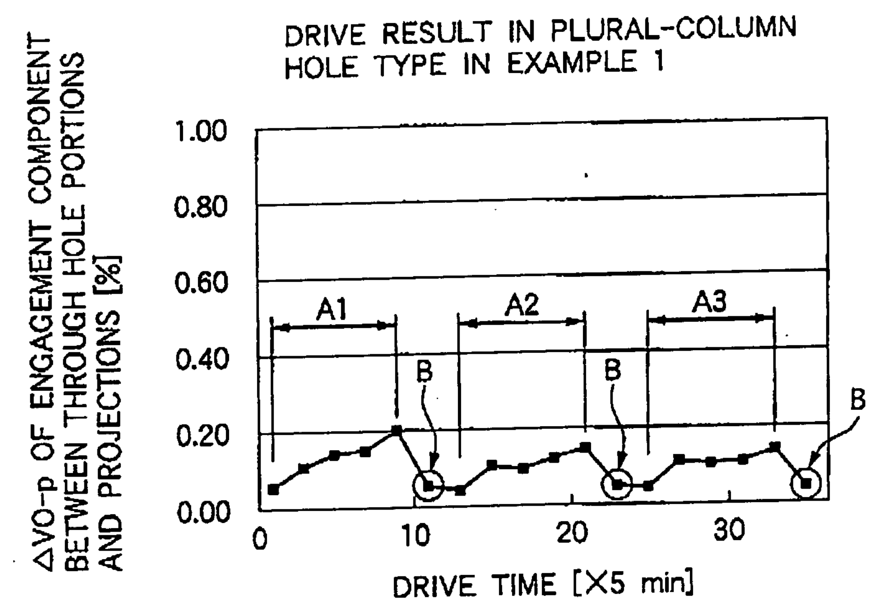

DRIVE RESULT IN PLURAL-COLUMN HOLE TYPE IN EXAMPLE 1
ΔVO-p OF ENGAGEMENT COMPONENT BETWEEN THROUGH HOLE PORTIONS AND PROJECTIONS [%]
1.00
0.80
0.60
0.40
0.20
0.00
A1
A2
A3
B
B
B
0
10
20
30
DRIVE TIME [X5 min]

FIG. 17

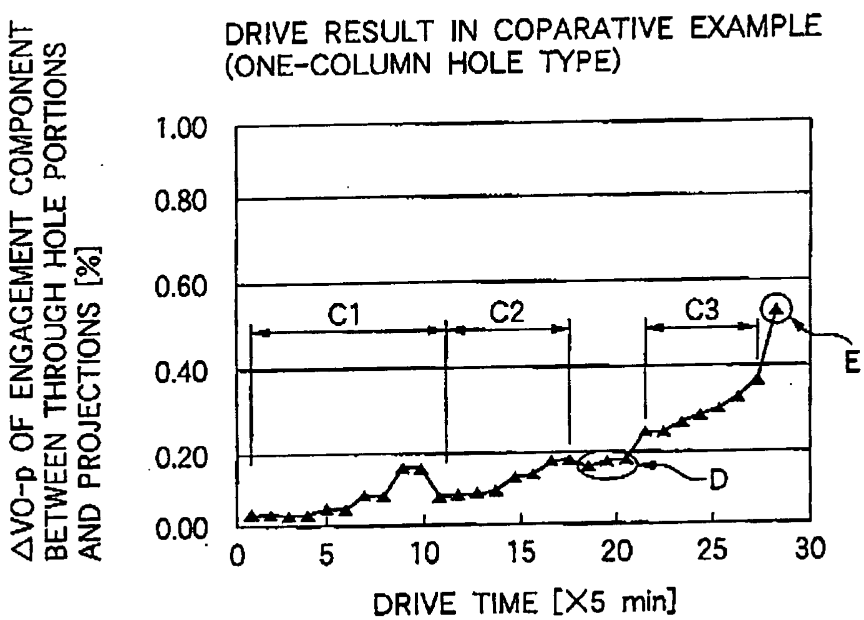

DRIVE RESULT IN COPARATIVE EXAMPLE
(ONE-COLUMN HOLE TYPE)
ΔVO-p OF ENGAGEMENT COMPONENT BETWEEN THROUGH HOLE PORTIONS AND PROJECTIONS [%]
1.00
0.80
0.60
0.40
0.20
0.00
C1
C2
C3
D
E
0
5
10
15
20
25
30
DRIVE TIME [×5 min]

FIG. 18

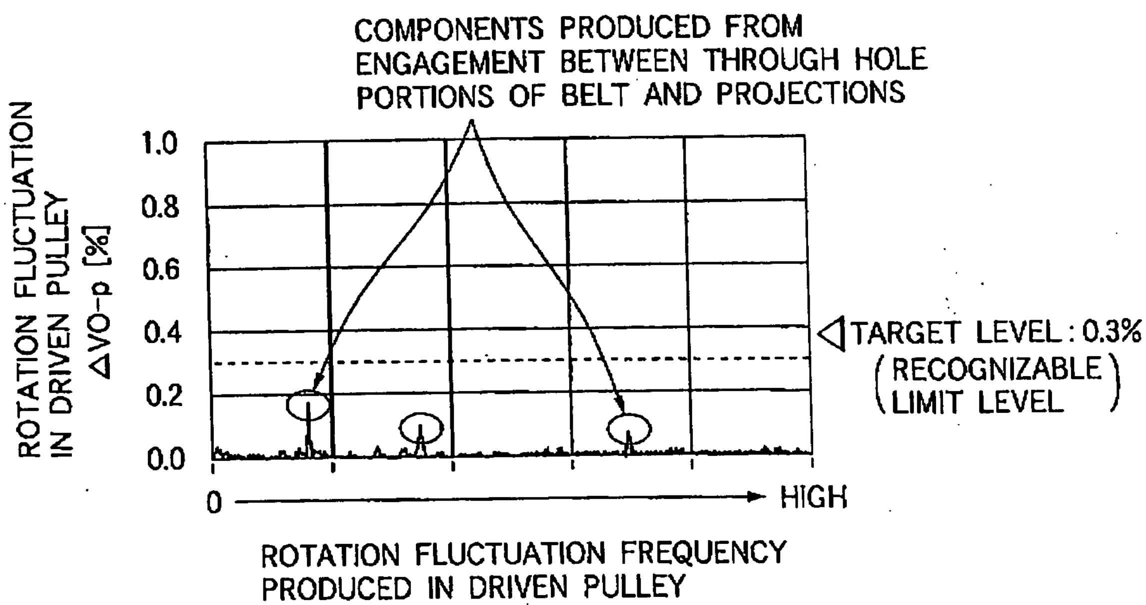

COMPONENTS PRODUCED FROM ENGAGEMENT BETWEEN THROUGH HOLE PORTIONS OF BELT AND PROJECTIONS
ROTATION FLUCTUATION IN DRIVEN PULLEY ΔVO-p [%]
1.0
0.8
0.6
0.4
0.2
0.0
TARGET LEVEL: 0.3% (RECOGNIZABLE LIMIT LEVEL)
0
HIGH
ROTATION FLUCTUATION FREQUENCY PRODUCED IN DRIVEN PULLEY

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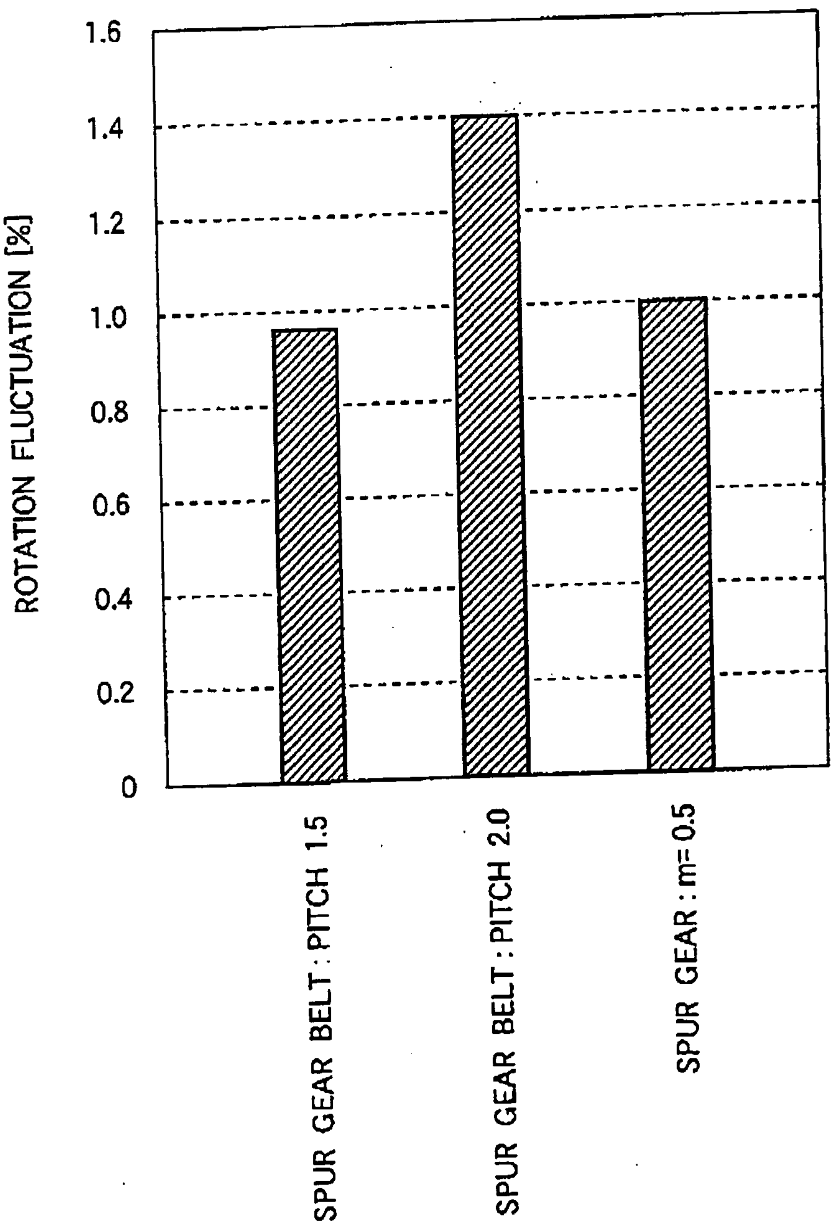
FIG.19



Received at: 10:23AM, 11/4/2003
03-11- 4;10:51PM;NGB OLIFF ;81355613954 #114/275

FIG.20

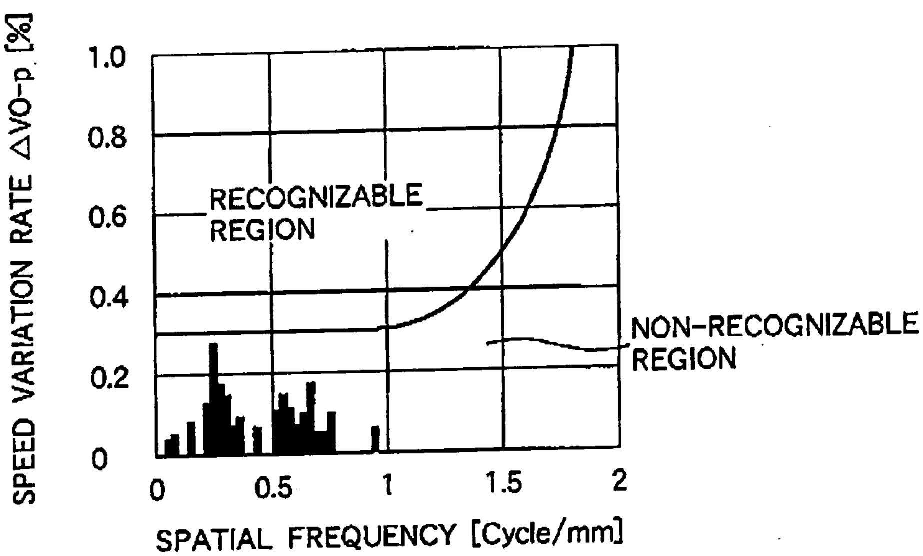


FIG. 21

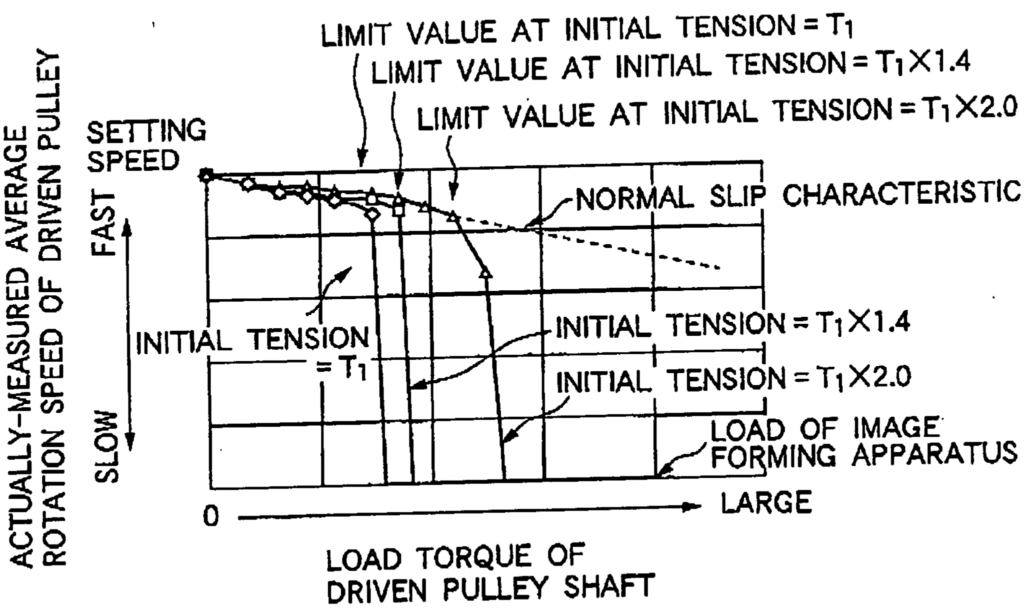
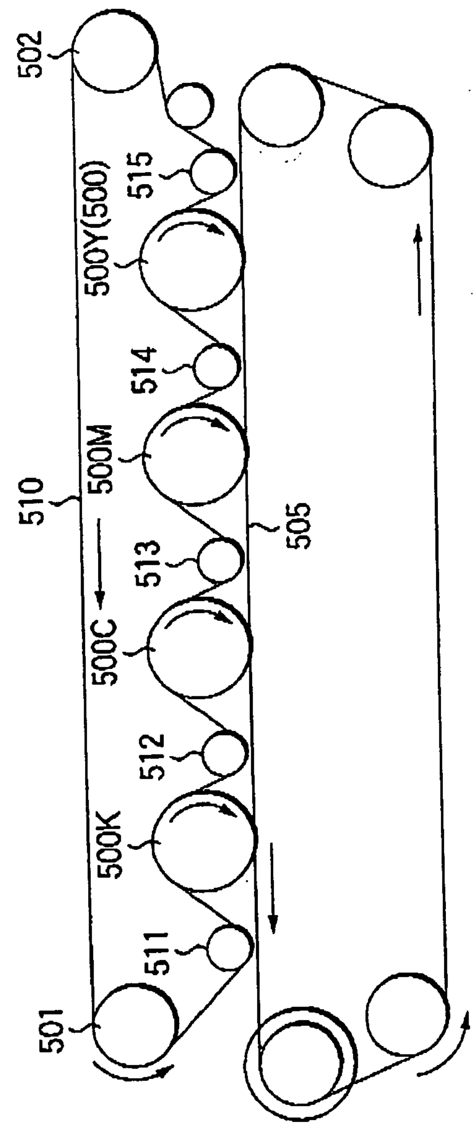
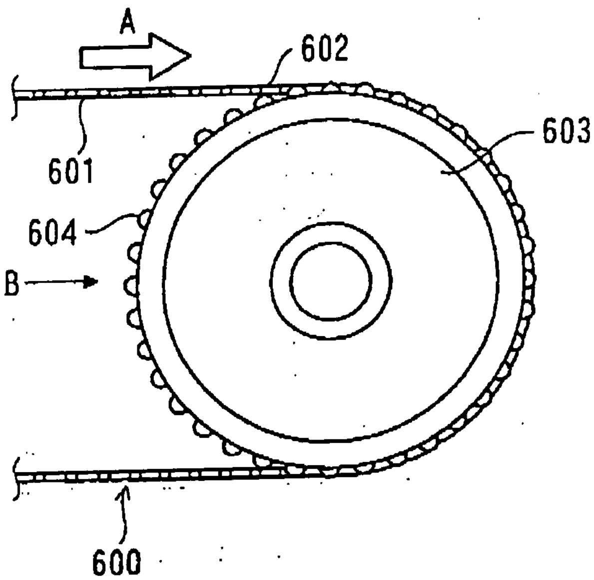

LIMIT VALUE AT INITIAL TENSION = T1
LIMIT VALUE AT INITIAL TENSION = T1×1.4
LIMIT VALUE AT INITIAL TENSION = T1×2.0
SETTING SPEED
NORMAL SLIP CHARACTERISTIC
FAST
SLOW
INITIAL TENSION = T1
INITIAL TENSION = T1×1.4
INITIAL TENSION = T1×2.0
LOAD OF IMAGE FORMING APPARATUS
ACTUALLY-MEASURED AVERAGE ROTATION SPEED OF DRIVEN PULLEY
0
LARGE
LOAD TORQUE OF DRIVEN PULLEY SHAFT

FIG. 22



【~~図２３~~】
Fig. 23

(a)



(b)

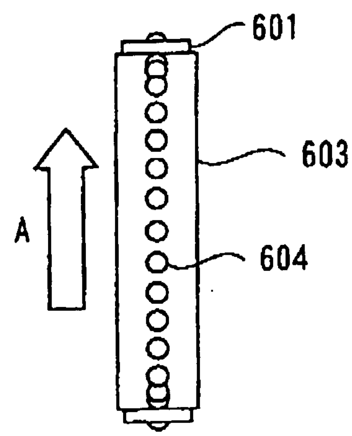
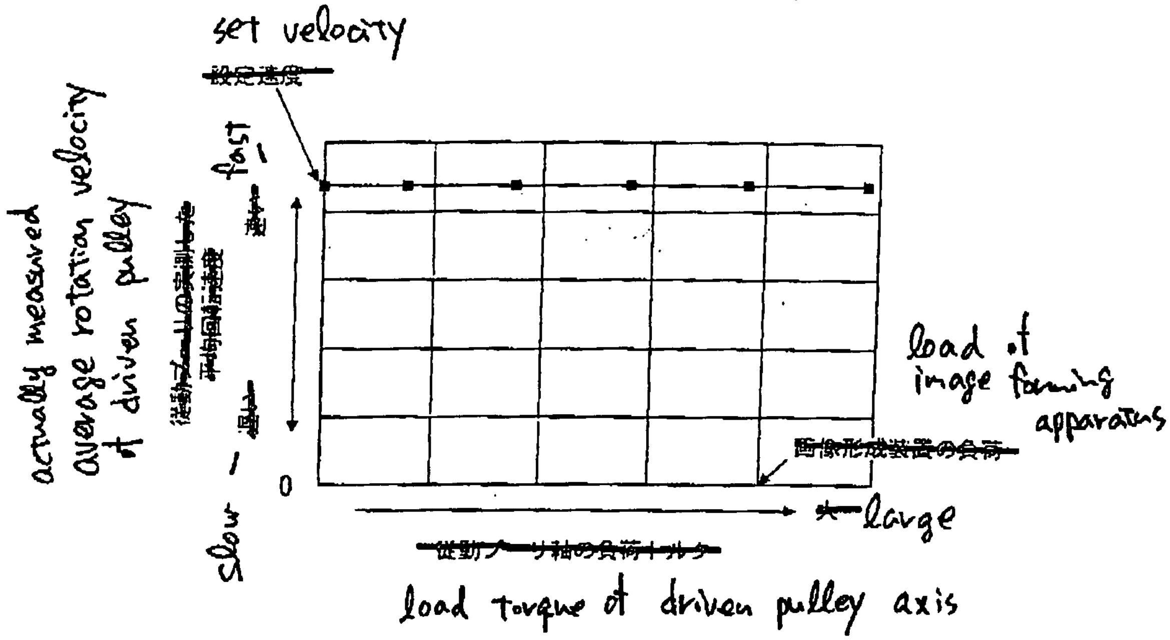


Fig. 24


set velocity
~~設定速度~~
actually measured average rotation velocity of driven pulley
fast
slow
0
load of image forming apparatus
~~画像形成装置の負荷~~
large
~~従動プーリ軸の負荷トルク~~
load torque of driven pulley axis